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A NEW MARKING SYSTEM AND MEANS OF MEASURING MATHEMATICAL ABILITIES.[1]

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Perhaps the most noted methods of measuring the intelligence of young children are the De Sanctis and the Binet-Simon tests. These tests apply mainly to the measurement of lower levels of intelligence. It is very significant that the noted Italian and French psychologists who originated these tests did not extend the general method to be used with pupils of the secondary and higher schools. In the present state of educational psychology it does not seem practicable or possible to effect successfully such an extension; that is to say, it is improbable that such tests can be devised which can be applied to everyday use in our schools, and will be a real improvement upon our present system of examinations, in settling questions of promotion and in awarding honors in our high schools and colleges. We are able to determine certain questions of athletic proficiency by measuring the high jump or broad jump, by timing the quarter-mile or half-mile run. The fact that the candidate knows beforehand the nature of the test does not materially interfere with its efficiency. But if a candidate for promotion knows beforehand the exact nature of the test in algebra—as he easily may know, if tests are adopted to be used by all teachers at all times—then he can easily learn the few tests and make a high grade, even though his knowledge of the entire subject may be woefully deficient. It is quite evident that it is impossible to formulate specific questions in any branch of high school mathematics, which could be used everywhere and at all times. Yet the report of the American Committee No. VII on Examinations in Mathematics, contains the following:[2]

"There seems to be a pronounced desire throughout the country for standardized tests in mathematics, that is, tests which will

[1] Read before The Mathematics Section of Central Association Science and Mathematics Teachers at Des Moines, Iowa, November 29, 1913.
[2] U. S. Bureau of Education, *Bulletin*, 1911, No. 8, p. 13.

enable teachers to measure fairly accurately the efficiency of their instruction and to know whether their pupils are as proficient as those in other localities."

One way to meet this demand is to prepare a syllabus of essentials in high school arithmetic, algebra and geometry, to be used in preparing the specific questions for an examination. Such a syllabus has its merits and also its demerits. Its merits are that both teachers and pupils have the territory to be covered by the examination more definitely limited to what are the essentials. Its demerits are that it leads both teachers and pupils to a disregard of the many minor facts of a science, which deserve at least passing notice. Nor does the use of such a syllabus prevent the selection by one teacher of only easy exercises, and by another teacher of only hard exercises. It is my opinion that the value of a syllabus is overestimated, that our high school text-books do not differ widely in the amount of material, nor in the degree of difficulty of the exercises contained therein. If a teacher carefully prepares a set of questions which, taken as a whole, are of average difficulty, he may rightly assume that he has a standard test. Notice my use of the word "carefully." No system of marking, however perfect, can be successful, if the teacher does not exercise *care*. A 12-inch disappearing gun will not defend Panama unless there is a careful eye to train it.

Granted that a standard set of questions is at hand, are our difficulties solved? Have we an absolute system of marking? By no means. Everyone knows that two teachers seldom agree on the marking of the same examination paper. They differ often by 10 or 20, and sometimes even by 30 points on the scale of 100. Suppose a pupil in algebra makes a mistake in algebraic sign, but otherwise answers a question correctly. One teacher will attribute the error to mere oversight, and mark the question nearly perfect. Another teacher will be horrified at the ignorance of fundamentals, and will mark the same question nearly 0. Such discrepancies will arise even in the use of the Binet-Simon system. That system does not eliminate the lopsidedness of the examiner. One of the questions put to a child of ten is this: "What would you do if you were delayed in going to school?" Various replies may follow, as, for instance, "I would have to hurry," "I would have to run," "I would return home," "I would be punished," "The teacher would slap me," "I would not do it again." Do you believe that in such a variety of answers which children may give, any two examiners would agree in their markings? "I would be

punished" does not answer the question. Accordingly, some examiners would mark 0. Other examiners would say that the reply not only implies that the question was properly understood, but that the child's mind passed beyond the immediate reply, that it "would have to hurry," and gave expression to a possible consequence that was more remote and therefore indicative of greater intellectuality.

The diversity of estimates would be as conspicuous here as in any ordinary examination. As yet we are as far as ever from an accurate standard of marking.

But a more or less absolute standard of marking is the very thing we are after. We need a common mode of procedure, such that a mark of "excellent" in first year geometry, given by a teacher this year, means nearly the same thing as a mark of "excellent" in this subject that will be given by a teacher 20 years from now. We need a system of marking such that a mark expressed in numbers conveys to everyone a fairly uniform and definite idea of proficiency. During the last few years great progress has been made in devising plans toward achieving this end. What I shall present to you today contains little that is novel. In this matter I follow in the footsteps of Cattell, Colvin, Dearborn, Finkelstein, Foster, Hall, Herschel, Huey, Judd, Meyer, Sargant, Smith, Steele, Stevens, Starch[3] and others.

Our scheme of measuring mathematical abilities resolves itself into two parts, as follows:

1. A formula for "arraying" students in order of ability, that is, for determining the relative positions of the members of a class, so as to establish the order of merit, or the rank of each individual in the group. This formula furnishes also preliminary estimates of ability.

2. A revision of these preliminary estimates so as to supplant them by an absolute standard.

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[3] J. M. Cattell, *Popular Science Monthly*, Vol. 66, 1905, p. 367.
S. S. Colvin, *Education*, Vol. 32, 1912, p. 560.
W. F. Dearborn, *Bulletin of the University of Wisconsin*, 1910, No. 368.
I. E. Finkelstein, *The Marking System in Theory and Practice*, 1913.
W. T. Foster, *Science*, Vol. 35, 1912, p. 887; *Popular Science Monthly*, Vol. 78, 1911, p. 388; *Administration of the College Curriculum*, 1911, chap. 13.
W. S. Hall, SCHOOL SCIENCE AND MATHEMATICS, Vol. 6, 1906, p. 501.
W. H. Herschel, *Bulletin of Society for Promotion of Engineering Education*, Vol. 3, 1913, p. 529.
E. B. Huey, *Journal of Psycho-Asthenics*, Vol. 15, 1910, p. 31.
C. H. Judd, *School Review*, Vol. 18, 1910, p. 460.
M. Meyer, *Science*, Vol. 28, 1908, p. 243; Vol. 33, 1911, p. 661.
E. B. Sargant, *Nature*, Vol. 70, 1904, p. 63.
A. G. Smith, *Journal of Educational Psychology*, Vol. 2, 1911, p. 383.
A. G. Steele, *Pedagogical Seminary*, Vol. 18, 1911, p. 523.
W. L. Stevens, *Popular Science Monthly*, Vol. 63, 1903, p. 312.
D. Starch, *Psychological Bulletin*, Vol. 10, 1913, p. 74; *Science*, Vol. 38, 1913, p. 630.

Part I.

Mathematical ability depends in part upon knowledge of a subject and proficiency in carrying on accurately the mechanical operations connected with it. This kind of ability may be determined by the usual memory tests conducted from day to day in the class-room, and at longer intervals by examination.

Mathematical ability is measured also by the success in solving original exercises. These tests are made in daily work, and also in final examinations.

The observation of instructors and the teachings of the history of science suggest a still further test of mathematical power, namely, the diligence or tenacity displayed by a pupil in pursuing his work. A pupil of only average talents, but of great tenacity of purpose, may achieve more in life than a bright pupil of limited powers of application. A standard illustration is the case of Robert Mayer, who as a pupil made only a moderate record, but who, by his extraordinary tenacity of purpose, was led to the discovery of the law of the conservation of energy. In Germany and Switzerland this feature is being recognized in the records and reports of scholarship. When I was a boy I received two marks on every subject, one for *Fleiss,* or diligence, the other for *Fortgang,* or progress. In Germany this practice is in vogue today.

According to our scheme, the mathematical pupil is measured in three ways, as follows:

1. By memory tests.
   (a) In daily work.............. M_a
   (b) In examination .... M_b
2. By original exercises.
   (a) In daily work.............. O_a
   (b) In examination .... O_b
3. By diligence (tenacity) shown........... D.

How these marks should be combined might be a subject of legitimate debate. Following custom, we use the weighted arithmetic mean, as follows:

$$\text{Preliminary mark} = \frac{M_a + rM_b + sO_a + tO_b + uD}{1 + r + s + t + u},$$

where r, s, t, u are coefficients determining relative weights. What weight should be given to daily work, what to the examination? In different schools the weights vary from daily work $\frac{4}{5}$, final examinations $\frac{1}{5}$, to daily work $\frac{1}{2}$ and final examination $\frac{1}{2}$. A conservative estimate would be to take $s = 1$, $r = t = u = \frac{1}{3}$.

Part II.

After the relative place or rank of the students in a class has been determined by the process of Part I, we proceed to determine their marks on an absolute scale. We shall assume that the pupils constitute a random sample or "fair sample" of the student body. What is the distribution of mental ability, and of mathematical ability in particular? No one has been able to give a final answer to this question. Francis Galton, Karl Pearson and

others have held that individuals differ from each other in ability in such a way as to conform with what is known as the "normal frequency curve" or the "normal curve" or the "gaussian curve." Distances along the horizontal line measure the students' abilities. The corresponding ordinates of this bell-shaped curve indicate the frequency. In measuring physical characteristics, it is easy to tell whether or not the above curve represents the proper distribution. It is a singular fact that this curve has been found to represent a general biological law of variation. Natural phenomena, as well as chance, tend to fluctuate in a number indicated by this curve. Chest measurements on 5,738 soldiers show the close agreement with theory.[4] The stature of 1,052 English women[5] was found by Karl Pearson to closely obey the gaussian law. Some of the lower mental traits can be measured in the psychological laboratory. Thorndike[6] found twelve-year-old pupils to be distributed according to the gaussian curve as regards their accuracy and rapidity of perception. Memory tests yielded similar results. When it comes to tests of higher intellectual powers, records are discordant. Different examiners have varied to such a marked degree in marking the same individuals that conclusions cannot be safely drawn from their estimates. On account of the presence of constant errors, the lopsidedness of individual markings of students cannot be altogether eliminated

[4] L. A. J. Quetelet, *Lettres sur la théorie des probabilités*, p. 400. See also A. L. Bowley, *Elements of Statistics*, London, 1902, p. 278; Dearborn, *op. cit.*, p. 8.
[5] Cattell, *op. cit.*, p. 371; Dearborn, *op. cit.*, p. 9.
[6] Thorndike, *Educational Psychology*, p. 15.

by taking the averages of many grades from different examiners. A curve constructed from 1487 grades in mathematics given by 19 different teachers in three high schools in Colorado exhibits two peaks with a valley between. The first peak is at 70 per cent, the passing mark; the other peak is just above 85 per cent. Evidently the peak at 70 per cent is due to a constant error arising from the practice of raising marks of some pupils to the passing grade. Such constant errors arise also where a mark of 85 per cent on the daily work exempts students from final examinations. It is found that in such cases medium grade students are advanced to the exempt limit. Seldom are marks given between 55 and 59, where 60 is the passing grade. If a doubtful student is finally passed, some teachers give him a mark considerably above passing, the idea being[7] that, if passed at all, he ought to be passed "handsomely." The tendency to mark high is inherent in human nature. Dr. Ruffner says[8]: "A temporizing professor who loves popularity, and desires, like the old man in the fable, to please everybody, is sure to be guilty of this fault, and, like many a politician, to sacrifice permanent good for temporary favor." For these reasons, available statistics as to the distribution of mental abilities are inconclusive. Some empirical curves indicate considerable skewness, others follow the gaussian curve. President Foster found that 8,969 grades in 21 elementary courses for two years at Harvard obeyed the normal curve of frequency. Dearborn reports similar reports for 472 high school pupils, also for freshman grades of these same pupils at the University of Wisconsin. It is doubtless the principle of continuity that has led not only English statisticians like Gatlon and Pearson, but also American investigators, Foster, Meyer, Smith, Dearborn, Finkelstein and others, to aver that the gaussian curve or normal curve is the proper curve for the distribution of marks in school. In what follows we assume that the gaussian curve can be so used.

The question then arises, what marks should be assigned to a random group or "fair sample" of, say, twenty students, whose order of rank is known by the tests suggested in Part I. This question involves some intricate statistical theory, which has been worked out by Karl Pearson. Pearson[9] states the problem thus:

"A random sample of n individuals is taken from a population of N members which when N is very large may be taken to obey

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[7] Finkelstein, *op. cit.*, p. 42.
[8] Qusted by Finkelstein, *op. cit.*, p. 47.
[9] Karl Pearson, "Note on Francis Galton's Problem," *Biometrica*, Vol. 1, pp. 390-399.

any law of frequency expressed by the curve $y = N\phi(x)$, $y\delta x$ being the total frequency of individuals with characters or organs lying between x and $x+\delta x$. It is required to find an expression for the average difference in character between the pth and the $(p+1)$th individuals when the sample is arranged in order of magnitude of the character."

In answering this question, Pearson derives complicated formulas which we have used in calculating our data. Pearson himself felt that he had solved an important question, for he said, "This difference problem marks a new and very probably most important departure in statistical theory." Clearly a knowledge of the average difference in scholarship of adjacent individuals supplied by Pearson's formulas, involves also a knowledge of the average difference in scholarship between any two individuals. We shall display in our tables the difference between the modal or most frequent scholarship of the class and the scholarship of any individual in the class.

The columns headed "mark/s" signify the ability of the pupil above or below the modal ability, divided by s, the standard deviation of the total group of students (say first year high school students) from which the particular class is taken at random as a "fair sample." It will be noticed that a large standard deviation indicates a large range of distribution—that is, a large difference of accomplishment between the best and poorest in the class. In freshman classes the standard deviation is apt to be large, because of great difference in preparation. For our purposes, the exact value of the standard deviation is of no interest. We are concerned more with the ratios of differential abilities, than with their absolute values. Hence we shall take $s = 1$, or if more convenient, $s = 10$.

Consider a class of 20 pupils. The modal or "mediocre" ability is taken here, as in the other cases, as the standard of reference and is marked 0. Abilities of students are arranged symmetrically above and below and marked positive and negative. By subtracting the ability of a pupil of rank n from that of his neighbor below, we get the differential ability of the two. In a class of twenty the difference in average ability between the tenth and eleventh pupil is .13. The difference between the first and second pupil is .5. Thus the difference between the first and second pupils is about four times greater than the difference between the tenth and eleventh. Similar statements apply to the poorest pupil and the one next above him. These relations are brought out by the adjoining figure.

AVERAGE DIFFERENTIAL ABILITIES OF PUPILS CHOSEN AT RANDOM.[10]

Arbitrary Divisions.	Class of 20.		Class of 30.		Class of 40.		Class of 50.		Class of 100.[11]	
	Rank	Mark/s	Rank	Mark/s	Rank	Mark/s	Rank	Mark/s	Rank	Mark/s
EXCELLENT. Above +1.5	1	1.9	1	2.1	1	2.2	1	2.3	1	2.5
			2	1.6	2	1.8	2	1.9	2	2.2
					3	1.5+	3	1.6	3	2.0
									4	1.8
									5	1.7
									6	1.6
									7	1.5+
SUPERIOR. +.5+ to +1.5	2	1.4	3	1.4	4	1.4	4	1.5	8, 9	1.4
	3	1.1	4	1.2	5	1.2	5	1.3	10, 11	1.3
	4	.9	5	1.0	6	1.1	6	1.2	12, 13	1.2
	5	.8	6	.9	7	1.0	7	1.1	14, 15	1.1
	6	.6	7	.8	8	.9	8, 9	1.0	16, 17	1.0
			8	.7	9	.8	10	.9	18-20	.9
			9	.6	10	.7	11	.8	21-23	.8
					11	.6	12, 13	.7	24-26	.7
					12	.6	14	.6	27-29	.6
							15	.6	30, 31	.5+
MEDIUM. —.5 to +.5	7	.5	10	.5	13	.5	16	.5	32, 33	.5
	8	.3	11	.4	14, 15	.4	17, 18	.4	34-36	.4
	9	.2	12	.3	16	.3	19, 20	.3	37-40	.3
	10	.06	13	.2	17, 18	.2	21, 22	.2	41-44	.2
			14	.1	19	.1	23, 24	.1	45-48	.1
			15	.04	20	.03	25	.02	50	.01
			16	—.04	21	—.03	26	—.02	51	—.01
	11	—.06	17	—.1	22	—.1	27, 28	—.1	53-56	—.1
	12	—.2	18	—.2	23, 24	—.2	29, 30	—.2	57-60	—.2
	13	—.3	19	—.3	25	—.3	31, 32	—.3	61-64	—.3
	14	—.5	20	—.4	26, 27	—.4	33, 34	—.4	65-67	—.4
			21	—.5	28	—.5	35	—.5	68, 69	—.5
INFERIOR. —1.5 to —.5+			22	—.6	29	—.6	36	—.6	70, 71	—.5+
	15	—.6	23	—.7	30	—.6	37	—.6	72-74	—.6
	16	—.8	24	—.8	31	—.7	38, 39	—.7	75-77	—.7
	17	—.9	25	—.9	32	—.8	40	—.8	78-80	—.8
	18	—1.1	26	—1.0	33	—.9	41	—.9	81-83	—.9
	19	—1.4	27	—1.2	34	—1.0	42, 43	—1.0	84, 85	—1.0
			28	—1.4	35	—1.1	44	—1.1	86, 87	—1.1
					36	—1.2	45	—1.2	88, 89	—1.2
					37	—1.4	46	—1.3	90, 91	—1.3
							47	—1.5	92, 93	—1.4
POOR. Below —1.5									94	—1.5+
									95	—1.6
									96	—1.7
									97	—1.8
					38	—1.5	48	—1.5	98	—2.0
			29	—1.6	39	—1.8	49	—1.9	99	—2.2
	20	—1.9	30	—2.1	40	—2.2	50	—2.3	100	—2.5

Distances measured to the right and left of the zero point signify abilities above and below the modal ability. The relative standings of the members of an average class of 20 are indicated by the dots. Observe the denseness of the dots near the modal position and the isolation of those at the ends.

When the number of pupils in a class is larger, the differential ability of the pupils ranking next to each other becomes smaller. Thus in a class of 100, the difference between the first and second

10 For practical use this table should be considerably extended.
11 The marks for a class of 100 are adapted from the tables of H. L. Moore's *Laws of Wages*, New York, 1911, pp. 98, 99. Moore computed his tables to six decimals. He applies Pearson's statistical theory to the study of "wages and ability."

is on an average .3, that between the 50th and 51st is on an average, .02, but the former difference is about 15 times greater than the second. The importance of these relations is brought out by Pearson in the following words:

"It is not possible to pass over the general bearing of such results on human relations. If we define 'individuality' as difference in character between a man and his compeers, we see how immensely individuality is emphasized as we pass from the average or modal individuals to the exceptional man. Differences in ability, in power to create, to discover, to rule men, do not go by uniform stages. We know this by experience, but we see it here as a direct consequence of statistical theory, flowing from a characteristic and familiar chance distribution. We ought not to be surprised, as we frequently are, at the results of competitive examination, where the difference in marks between the first men is so much greater than occurs between men towards the middle of the list. In the same way the individuality of imbeciles and criminals at the other end of the intellectual and moral scales receives its due statistical appreciation."

The total range of distribution for classes of random pupils not exceeding 100 is about 2.5s on each side of the modal line, where s is the standard deviation. Taking $s = 1$ or $s = 10$ we have a scale for marking, the objection to which lies mainly in the fact that it is new. But this scale is the most scientific yet proposed. It is based on careful, statistical theory.

The mode of distribution of mental abilities, exhibited in the normal curve, suggests that the scale be subdivided into an odd number of parts, so that there may be a central group, representing average students, which is the most common type of students. The other groups are placed symmetrically above and below this central group. What should be the total number of groups? Experience shows that three groups are hardly sufficient, that seven groups are excessive. The five-group system is altogether in nearest accord with experience. Accordingly, we shall use the terms "Excellent," "Superior," "Medium," "Inferior," "Poor," and define their positions on the Pearson scale, thus:

POOR.	INFERIOR.	MEDIUM.	SUPERIOR.	EXCELLENT.
Below —1.5	—1.5 to —.5+	—.5 to +.5	.5+ to +1.5	Above +1.5

When a class of 20, 30 or 40 pupils has to be marked, we first determine the ranks of the pupils. Then the numerical values of these tables are a suggestion as to the probable marks to be assigned. For any one class of 20 these tabular figures are, of

course, not binding. If a large number of different classes of 20 could be marked with absolute accuracy, the *averages* of the marks of all the pupils that take the rank *n* in the lists of twenties would yield the values given in the tables. Thus the averages of the students ranked fifth in different classes of twenty students each, is .8. What deviation from the tabular marks should be made in the case of any particular class because of its individual variation or its deviation from a "fair sample" must lie with the judgment of the instructor. The position of the exact line of cleavage between pupils "passing" and those "not passing" must rest with him. It is my own judgment that, *if teachers were to follow very closely the tabular marks, and were to modify them in only exceptional cases, and then only slightly, that a great stride would be taken toward a scientific and absolute method of marking.* Gross irregularities in marking, such as Finkelstein has found in Cornell, and such as we know to exist in schools with which we are connected—irregularities working great injustice to pupils aspiring to honors and to scholarships—would be eliminated by the adoption of a plan as herein set forth. Everyone knows that the marking system as carried on at present in high schools and colleges is a farce. But the adoption of a scheme of marking as here proposed would show that a mark of 0 places the pupil in a modal position, as a mediocre student. A mark above 1.5 places him in the list of the very few branded "excellent." A mark below —1.5 places him near the line of students marked "not passed."

In nearly all the marking systems that have been suggested in recent years, the recommendation is made that, under normal conditions, a certain percentage of the class be marked "excellent," another percentage "superior," etc. The Missouri plan involves the same idea by dividing each class of 100 into four groups of 25 students each, and then subdividing the first and last groups again into two classes. I have never seen it pointed out that *such a procedure, as a matter of fact, rests upon an unsound basis.* The tabular data computed from Pearson's formulas show that if, for instance, we mark 7 per cent of a class of 100 "excellent," we have a different standard of "excellence" from what we have when 7 per cent of a class of 50 is marked "excellent." The difference in standard is slight, but it exists, and therefore renders the percentage basis scientifically objectionable. To illustrate: When 7 per cent of the class are marked "excellent," the lower limit for this mark on the Pearson scale is (using more accurate results than those in our table) 1.4390 for a class of 100,

1.4045 for a class of 50, 1.3951 for a class of 40, 1.3529 for a class of 30, and 1.3080 for a class of 20. Seven per cent of a class of 51 members is four, but only three of the four stand above the point 1.4390 on the Pearson scale. In other words, on the 7 per cent basis of excellence, the grade "excellent" is easier to reach in a small class than in a large one. If a class is divided arbitrarily into four groups, equal in number, as in the Missouri system, then the lower limit of merit for the top group is .6588 for a class of 100, .6368 for a class of 40, and .5972 for a class of 20. Twenty-five per cent of a class of 51 members is 13, but only 12 of these have a mark above .6588 on the Pearson scale. Such variability of standards does violence to our sense of scientific rigor, though the practical results do not usually differ, owing to the fact that in practice only integral numbers apply.

In a scientific marking system the first requisite is uniformity of standards of reference. Lack of uniformity is sufficient reason for rejecting the classification into groups on the percentage basis, as in the Missouri system and others, unless that basis has some advantages which compensate for its theoretical defects. Such advantages it is difficult to discover.

To summarize, our proposed plan of marking is as follows:

1. A system of preliminary marking is used, merely to determine the rank of the students.
2. After the rank is fixed, students are assigned the marks given in our table, with such slight modifications of the marks as are necessary in the judgment of the instructor.

The advantages of this system are:

1. It rests upon correct statistical theory.
2. The groups called "superior," "medium," "inferior," cover equal ranges of ability. These ranges are constant, no matter what the size of the class may be. Neither the top group called "excellent," nor the bottom group called "poor" has a fixed extreme limit, thereby providing, as the system should, for the grading of men of genius at one end and of the intellectual sluggards at the other.
3. It tends to eliminate the personal equation of the examiner.
4. The method is absolute, except in the determination of deviations of the marks of a class from the *average* marks of classes of that size.

"This is a complicated system," you will say. So it is, though not quite so complex, perhaps, as it appears at first sight. Chemists and physicists know that any process of exact measurements requires time, patience and skill. That is true of our plan.

DEVELOPMENT WORK IN ARITHMETIC.

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Arithmetic should be taught in such a way that the number facts learned may be usable in the life of the child, and also usable in the everyday life of the individual after leaving school. To secure this result in our school work two factors of arithmetic need special emphasis, namely:

1. The removal of all mystery in the fundamental operations and principles of number relations.
2. The application of the number facts through practical problems to bring the child into vital touch with actual business and industry.

It is the purpose of this article to discuss the first factor only.

The principles of arithmetic should be developed in such a way that all mystery in the mechanical operation be removed. In most, if not in all cases, this can best be done by the inductive method. Here we may use the five formal steps of the Herbatian lesson plan, namely, preparation, presentation, comparison, generalization, and application. The first step should be the need on the part of the pupil for the principle. This should be a childish need, or one within the experiences of the child, but it is the duty of the teacher to create this need. Feeling the need for the principle the pupil has the aim. For example, we have come to the time when we want to teach formal multiplication of fractions. We may have in some of the pupils' work measurements involving $\frac{3}{4}''$. This measurement is used a number of times, say five. The question is how many inches in all. From what the child already knows he will add thus, $\frac{3}{4}''+\frac{3}{4}''+\frac{3}{4}''+\frac{3}{4}''+\frac{3}{4}'' = {}^{15}\!/\!_{4}'' = 3\frac{3}{4}''$. Since the addends are all alike how else may we secure the results? The child will know from his previous work in integers that it is by multiplying.

The second step is the securing of data from which the principle may be derived, for no one can reason without data. Here again it is the function of the teacher to supply this data. To continue our illustration of the multiplication of fractions by an integer several problems are given similar to the first, as,

$$4\text{x}\tfrac{2}{3} = ?$$
$$4\text{x}\tfrac{3}{5} = ?$$
$$5\text{x}\tfrac{2}{7} = ?$$
$$2\text{x}\tfrac{3}{4} = ?$$

each problem being solved by the pupil as follows:

$4\times\frac{2}{3} = ?$ $\quad \frac{2}{3}+\frac{2}{3}+\frac{2}{3}+\frac{2}{3} = \frac{8}{3}.$

$4\times\frac{3}{5} = ?$ $\quad \frac{3}{5}+\frac{3}{5}+\frac{3}{5}+\frac{3}{5} = \frac{12}{5}.$

$5\times\frac{2}{7} = ?$ $\quad \frac{2}{7}+\frac{2}{7}+\frac{2}{7}+\frac{2}{7}+\frac{2}{7} = \frac{10}{7}.$

$2\times\frac{3}{4} = ?$ $\quad \frac{3}{4}+\frac{3}{4} = \frac{6}{4}.$

The question mark is removed and the product placed after the equality sign.

The third step leads to a comparison of results by skilful questioning on the part of the teacher, as, what is the relation of the numerator of your product and the numerator of your multiplicand in the first? the second? and so on through. How then may we obtain the same product other than by adding? With all the concrete problems before them the pupils will DISCOVER that the same result may be obtained by multiplying the numerator of the fraction by the whole number and writing the result over the denominator. This is our fourth step or generalization. At once we should test the principle suggested by the students. A good method is to let each pupil make his own problem, solve it by applying the new principle and then check his result by adding thus, $5\times\frac{4}{7} = \frac{20}{7}$.

Check $\quad \frac{4}{7}+\frac{4}{7}+\frac{4}{7}+\frac{4}{7}+\frac{4}{7} = \frac{20}{7}.$

Since the rule holds good for so many problems we will consider it correct for all problems. Lastly comes the application or drill until the new principle becomes a fixed habit of control.

The fourth step is deductive reasoning, but quite as necessary as the preceding steps. In fact induction and deduction are not distinct in the sense that sometimes we use the one and sometimes the other. Charters says, "They are complementary to each other."[1] We are emphasizing the inductive method when we lead from the particular to the general, and the deductive method when we lead from the general to the particular. After the principle is established inductively with small numbers it should be used deductively with larger numbers, if larger numbers are used at all.

To be sure the principles of arithmetic may be taught either inductively or deductively as a mere learned fact. Thorndike says, "Indeed the mere mechanical learning of the procedure may seem to many the most economical method. It should, however, be noted that such mechanical learning is really inductive, the generalization coming after much drill and being in the form, 'This procedure is right because it always gives the right answer,' the

[1] *Methods of Teaching.*

teacher's word or the answer-key being the means of verification."[2]

In development work free mental activity should always be aimed at, but the teacher should guide the pupils by questioning in such a way that time will not be wasted in random guessing, or in wandering from the aim.

After the principle has been established by the pupils they should not be expected to repeat and repeat it in verbal form, but should be led to express themselves in number form. If a pupil is able to multiply a fraction by a whole number, and has removed all mystery as to the mechanical process, why should he be expected to repeat the principle continually, or to tell how it was derived? The thing to do is TO USE IT until the process becomes automatic.

Each new principle or operation should not be learned as a separate, unrelated operation. The teacher should know her pupils thoroughly in order that she may draw upon their past experiences in developing the new work. For example, they know that multiplication of integers is only a short process of addition where the addends are all alike, and should be led to see that this fact holds true in fractions. The only new thing here is the handling of the numerator. Our teaching process thus becomes a leading from the old to the new. Mr. Courtis says, "It seems practically certain that in the present state of our arithmetic teaching each operation and each part or division of a topic is learned by the child as a separate, unrelated activity. There is no co-ordination, no welding of separate parts into one science of number, no appreciation of the meaning and purpose of arithmetic as a whole. Accordingly the incidental emphasis of the teacher on one topic or another, due to the varying mentalities of the different classes of the same grade, leaves a lasting bias toward skill in one operation or another."[3] There is nothing that will remove this save a logical arrangement and a psychological development of the principles of arithmetic.

The inductive method of teaching necessitates concrete work, but concrete work does not necessarily mean that objects present to the senses be used. Object work is good, and in many cases indispensable, but it is often abused by its continued use after its usefulness has passed. In the use of objects care must be taken in selecting and varying the objects so that the object ceases to

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[2] *Education*.
[3] Thorndike's *Education*.

be the important thing leaving the number relation in the memory.

To summarize, it may be said there are five distinct advantages of this method over the deductive method, or the giving of the rule by the teacher or taking it from the book.

The first and most important advantage is that the work becomes a joy through the creative activity of the child. In speaking of this Suzzallo says, "When he (the child) has found the fact he has already learned it."[4]

In the second place he is led to an independent feeling instead of a dependent one. He no longer feels the need of the teacher as a crutch.

In the third place he is more able to apply the number facts to the arithmetical problems of life, because he understands the principle, and thereby understands the use to which it may be put.

In the fourth place he is more able to re-establish a forgotten principle. Since he has reasoned the principle out once he may be able to reorganize his known facts and thus to reason the organization out again.

In the fifth place he is more able to make "short cuts" in handling numbers. If he is given the principle usually he has to be given the short cut also as a separate and distinct operation.

[4] *The Teaching of Primary Arithmetic.*

A BULBOUS EPIPHYTE.

Epiphytes are plants which grow upon others without depending upon them for food. In temperate regions, many mosses, lichens and a few ferms are epiphytes, but it is not until the tropics are reached that we find flowering plants of this nature. In the tropical rain forest, however, there are numerous flowering plants that have become epiphytes, notably the orchids, the pitcher plants, and the plants of the pineapple family. The position of these plants on the trunks and branches of trees, prevents their absorbing water as needed, as plants rooted in the soil are able to do, and they are, therefore, obliged to keep pretty close to regions where the rainfall is frequent and abundant. As a rule the epiphytes possess cisterns or other devices for storing the precious moisture against a time of drouth. In a country where it is always summer there is no need for plants to store food and, as might be inferred, plants with bulbs, corms, or thickened rootstocks are exceedingly rare among epiphytes. A few species have bulbous parts, usually stems, but these are for the storage of water, not food. A remarkable exception to this condition is found in a new plant reported from South Africa in which there is a bulb of the conventional style. The plant belongs to the Amaryllidaceae and has been named *Cyrtanthus epiphyticus*. It is said to be the first Amaryllidaceous plant recorded as an epiphyte. The plant grows with its bulb embedded in the moss on the trunks and branches of a species of yellow wood *(Podocarpus)*.—*American Botanist.*

THE VOCATIONAL ASPECT OF COMMERCIAL GEOGRAPHY.

By Alison E. Aitchison,
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Whether one defines commercial geography as that branch of geography which traces the influence of natural factors in the production, transportation and exchange of commodities or limits it, as some would, merely to the influence of those factors in the transportation and exchange, the same demands which called it to a place in the curriculum of the ordinary high school some years ago, now call for its retention in the courses in the vocational high school.

In the early days of our country's history when the farm home was the center of various productive activities which supplied very largely the simple wants of the household, the child grew up with an intimate knowledge of many of the processes involved in the industries which furnished his food, clothing and shelter. This stage lasted long in America as we possessed for scores of years, a long western frontier, remotely situated from the factories which grew up in the path it had left. In those early days when employer and employee were identical, when capital and labor agreed, when the interests of the community were not so diversified, town and country were not far removed in sympathy, one from the other, the processes of production were simple, transportation was too costly to be extensive and exchange involved no complicated system of wholesalers, drummers, retailers and numberless middle men. In these later days of large urban centers, of little contact between town and country life; these days of great factory systems, of division of labor and segregation and centralization of industries, the child is cut off from all practical knowledge of all these things and because of our complex commercial system, he misses many of the points of contact between his life and the activities of others and loses sight altogether of his relation to the industries which condition his own comfort and progress.

A present day writer on education has said: "The tendency of modern education is to lessen the gap that has long existed between school and life." This in part will be the work of the vocational schools, yet there is danger in these schools, that the vocational part of the work may be too violently or, perhaps, too distantly separated from those studies which we have been justly regarding necessary as the basis of a good education.

There are some branches that in themselves contain the elements which will bring into closer union the vocational studies, the natural materials of which they make use of and the scientific world which has improved and made possible the industries as they exist today. Commercial geography may properly be considered one of these linking subjects. A boy in the manual training shop may be working at the forge—if his commercial geography has taught him the location of the great iron ore beds of the United States; the immense transportation systems which are needed to carry the ore to the blast furnaces of Pennsylvania, Ohio, or Illinois; has given him some idea of the work done in preparing the pig iron; has shown him the importance of the iron and steel industry in the economy of the country and its benefit to the United States in its struggle for commercial rank; his work may be no better so far as the mechanical output is concerned, but it has attained a different setting and he realizes his relation to and his dependence upon other laborers scattered throughout a dozen states.

Commercial geography gathers up the loose ends left in the other science studies and unifies them by showing their relation to human society and human progress. Take for example the wheat growing industry. His work in the other sciences has given him the basal facts for interpreting correctly the climatic and soil conditions which determine the location of the world's great wheat fields, as soon as he learns from his commercial geography the specific requirements which wheat demands. His physical geography enables him to say not only where the rainfall is enough and not too much but why these conditions exist where they do and why they can not be expected in other places. His geology explains for him the soil conditions, his agriculture, why certain soils are adapted ot wheat growing—his botany shows him the wheat as a plant. Now, the commercial geography, at this point, gathers these facts together and shows why, because of these existing conditions, great transportation problems have had to be solved; enormous milling plants have come into existence and large cities have grown about them. It is a long story from the great ice sheet which was indirectly responsible for the level floor of the Red River Valley to the loaf of bread made by the girl in the cooking class but it is a study full of human interest, and one whose perusal will make the girl better able to understand some of the economic problems which face the country's future.

At this point in the discussion one statement must be made out of justice to the study itself. So long as commercial geography in the high school must be taught by anyone who happens to have a vacant period, be he German teacher, Latin teacher, or History teacher; by some one who has had no training in it or a kindred subject, it can have no definite relation to vocational subjects or, for that matter, to any other subjects. It will remain a unique and perhaps ornamental catch-all, useful as a piece of busy work but falling as far short of the good it might accomplish as the ordinary relief map falls short of the topography which it is meant to represent. The commerce of the world depends so largely upon physical and climatic factors that commercial geography, to give the best results, should be studied by pupils who have had a course in physiography. This is often not practicable. If the pupil has been well taught the geography ordinarily given in the grades and the teacher understands the subject matter well enough to discriminate between essentials and non-essentials, a fairly satisfactory course may be given without a preliminary course in physical geography. This then is a double reason why the teacher of commercial geography should be well prepared. Too many sins have already been committed in the name of the subject in the ordinary high schools to make advisable the committing of any more in the vocational schools.

The points at which commercial geography and the vocational subjects come into contact are numerous. For instance in the special courses offered in sewing a knowledge of the textiles from the geographic side, the parts of the world from which they come, the conditions under which they are produced and the centers where they are manufactured is very desirable. The boy working with the turning lathe works more as an intelligent citizen should work, with a greater appreciation of the value of the raw material which he handles, if he knows something of our dwindling lumber supply and the immense drain which we are making upon it yearly. A class in animal husbandry have wider horizons if they understand the reasons for the location of the great grazing regions of the United States—and their relation to the corn growing sections and to the great packing centers. In all commercial schools the importance of the study has long been recognized and one or two semesters or terms of it have been required.

To look at this from another standpoint any subject, any branch of geography which helps to familiarize the student with the exact locations of places, is of great benefit to him. The ignorance of

the ordinary high school or normal school, yes, or university, student on this point is appalling. In a test made on a class of university students, in one of the leading universities in the country, within the past year a number were unable to write the names of all the states into an outline map without making several mistakes. The same test tried last summer term with normal school students showed an unbelievable number of errors; Maine in southern United States; Michigan in Wisconsin; Virginia in New England; and other errors of equal magnitude. Cities were located anywhere and everywhere—New York a couple of hundred miles inland; Chicago a hundred miles from the lake; Minneapolis not within hailing distance of the falls; Galveston in central Texas. A study of these errors convinces one that the students examined had connected the cities in question with none of the causes which contributed to their growth, and that their retention was simply an act of memory. Commercial geography helps in fixing location because the reasons for the development of the city are emphasized. It would seem that one who has studied New York from the standpoint of its commercial relations to European countries would hardly be likely to think it near Syracuse or Rochester.

You who are not in sympathy with the subject may say much of this information which has been mentioned should be gained as a matter of general information from newspapers, from magazines, from the geography in the grades. Papers and magazines are not so accessible to all as they are to us; the geography in the common school generally ends with the seventh grade. If one stops to think of the endless arguments and speculations he has often heard made by people who have read an item in the newspapers concerning some place of which they knew nothing, he is forced to admit that a little accurate information concerning the products or industries of the place would sometimes have shown the absurdity of the whole discussion. For example; one might have judged from the wild statements made at the time of the great discussions on Canadian reciprocity, that the number of hides to be shipped into the United States from that country would seriously damage our business. As a matter of fact the total number of cattle in Canada very little exceeds that in the state of Iowa alone. As some one has cleverly said, "One might think, from the outcry against Canadian hides, that Canadian stock growers harvested a crop of hides from their cattle every year." Painful investments have been made in good farm lands

in the pine barrens, in irrigated fruit lands that had no markets, in northern farm lands with too short seasons, which might have been saved had people been trained to look on the geographical side of some of these commercial ventures.

Finally the last great reason for teaching commercial geography in the vocational high schools, a large per cent of these students go from the high school to the business world and any subject which helps them to take a more intelligent, more rational, more sympathetic view of human beings working under more favorable or more adverse conditions in other parts of the world, any subject which helps them to realize the dependency of one group of people upon another or to grasp more fully the dignity of their own labor in its relation to the whole scheme is well worth the time and effort which may be spent upon it.

AMERICA AS A GREAT RADIUM COUNTRY.

The special warrant for radium conservation in America is the fact that this country has become the greatest recognized source of the element. Joachimsthal, Austria, has been popularly regarded as the most important radium-producing district of the world, but the conclusion is a wrong one. During the last two years the carnotite ores of Southwestern Colorado and eastern Utah have yielded more radium than has been produced from the mines of Austria. The production was effected in Europe, it is true, but the origin of the raw material was America. In the future our country will continue to command the radium yield, which will come not only from the carnotite deposits, but from the pitchblende ores in Gilpin county, Colorado; these being the best known sources in the United States. It is not fair to the nation that we should not possess our own product, reduce it here, and control the radium supply for the service of our own scientific men. The significant thing about the radium situation, from the point of view of the laboratory, is that small amounts of the salts may not be expected to yield adequate results. It requires a considerable amount to enable the experimenter to bring his results within the range of fairly accurate observation. Dealing as he does with forces that are only indirectly measurable, and then only by the most delicate apparatus, he is bound to feel the lack of such quantities as may bring his notations within the range of certainty. Much emphasis has been laid upon the applications of radium to medical investigation, but we cannot give up the view that the broader benefits to pure science of the revelations concerning the constitution of matter should receive first consideration from the people. The reports which now and then creep into the press concerning the profound investigations of the radium workers are not a mere appeal to popular imagination, but the result of the most momentous revelations to chemistry since the discovery of the periodic law. They go deeper than the periodic law and bring us into an order of things that will require many a year to delve into. Radium seems so important to the world of science that it possesses a peculiar sanctity, and therein we find the explanation of the professional competition for the possession of it.—*Mining Science.*

VERIFYING THE LAWS OF THE PENDULUM.

By Edison Pettit,
High School, Minden, Nebraska.

The common laboratory experiment to verify the laws of the pendulum derives only the relation of the period to the length of the pendulum. The experiment as here outlined is designed to derive the formula $T=2\pi\sqrt{\frac{L}{g}}$, a formula which cannot be demonstrated mathematically to the elementary student.

First of all the student should learn in the course of his work in physics that when a quantity is found to vary according to several functions the numerical value of the quantity is equal to the product of the functions and a constant. The experimental results are then placed in the following form.

I. To determine what changes in the pendulum and forces acting upon it change the value of the period T.

Suspend several weights from the cross bar of the table such that the distances of the centers of gravity of the weights from the points of support are equal. Find the value of each period using the same arc of swing for each. Record your experiment as follows.

	Weight of Bob.	Time.	No. Vib.	T.
1.	....	......	......	......
2.	....	......	......	......
3.	....	......	......	......

Av. T =......, length =......, arc of swing =......

Select any one of the above pendulums and fill out the following form, keeping the length and weight of the pendulum constant.

	Length of Arc in Terms of L.	Time.	No. Vib.	T.
1.	03	.....	.....	.....
2.	06	.....	.....	.....
3.	08	.....	.....	.....
4.	1	.....	.....	.....
5.	5	.....	.....	.....

Keeping the arc of vibration and the mass of the bob the same, change the length of the pendulum. Attach a string to the bob and pull down on it. This has the same effect as if the force of gravity on the bob were increased without increasing its mass. State what your final conclusion is in regard to the effect of changes in the mass of the bob, the length of the arc of vibra-

tion, the length of the pendulum and the force of gravity on the value of the period T of the pendulum.

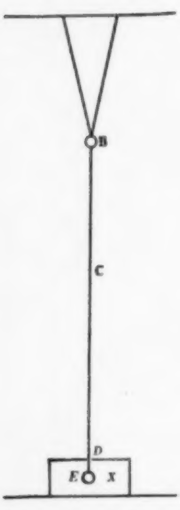
II. To derive the law of the pendulum.

Suspend a small heavy weight from a fixed support and record the experiment as follows (1):

L.	Time.	No. Vib.	T.	L.	$\sqrt{L.}$
1 ft.	......	......	......	......	......
2 ft.	......	......	......	......	......
3 ft.	......	......	......	......	......
4 ft.	......	......	......	......	......

How does the value of T vary with the length?

Suspend a 100 gm. weight from the ceiling by two cords to keep the pendulum vibrating in the same plane as in Fig. 1. To



this bob attach a cord C reaching to the floor, the longer the better. On the floor is a box X. A hole D admits the cord C. To a small hook on the end of this cord a weight E may be attached. Now suppose there is no weight at E. The only force acting on the bob B is the force of gravity g. If, however, we attach a weight at E equal to the mass of B, viz, 100 gm., it is evident that the force of gravity g acting on B is aided by an equal amount through E and the result so far as the pendulum is concerned is the same as if the force of gravity on the bob had been doubled, and if 200 gm. is placed at E the effect is the same as if the value of g had been tripled, etc. The cord C must be long in order that the force at E shall always act nearly in the direction of gravity. Fill out the following form for the results of the experiment (2):

Wt. of B.	Wt. of E.	Total Force at B.	Time.	No. Vib.	T.	g	$\frac{1}{\sqrt{9}}$
100 gm.	0 gm.	1 g.	...	...	...	...	...
100 gm.	100 gm.	2 g.	...	...	...	...	...
100 gm.	200 gm.	3 g.	...	...	...	...	...
100 gm.	300 gm.	4 g.	...	...	...	...	...

How does the value of T vary with the value of g?

Now if it is found that T varies directly with the square root

of the length and inversely with the square root of the value of g then (*a*) $T = K\sqrt{\frac{L}{g}}$. It remains to find the value of K.

Solve this equation for K obtaining $K = T\sqrt{\frac{g}{L}}$. Now the value of g has been obtained with the inclined plane or Atwood's machine and in (1) above we have the simultaneous values of T and L the variables, and g is a constant, hence these values ought to satisfy the equation $K = T\sqrt{\frac{g}{8}}$. Inserting these values then in the above equation, the value of K may be found. Insert each set of values determined for T and L exp. (1) together with g and take the average of the values of K so found as the vest value of K. If the complete vibration is used in exp. (1) this will be nearly 2π but if the beats were counted every time the bob crosses the center the value of K so determined will be π. Replacing this value of K in equation (*a*) we get $T = 2\pi\sqrt{\frac{L}{g}}$ which is the law of the pendulum. Solving this equation for g and repeating experiment (1) with careful measurements of T and L it is possible to obtain a very close value for g. The experiment is well adapted to the lecture table since it is a good example of the method of obtaining a formula from purely experimental results.

THE PASSING OF MALARIA.

At a meeting of the Royal Colonial Institute in London, recently, Dr. Malcolm Watson gave an account of his work in the prevention of malaria in the Federated Malay States. He showed that pool-breeding mosquitoes could be abolished by open drainage, that stream-breeders could not be so abolished, but required drainage, and that countries with no hill-stream breeders had no hill malaria. He described investigations which he had carried out in other parts of the world where malarious conditions more or less prevailed, in the Duars at the foot of the Himalayas, and in the Jeypore hills in Madras; in Sumatra, Panama, British Guiana and Barbadoes, and declared that the new knowledge had given absolute control over the malaria of low, flat land, and high hopes of control over that in hill land. There was also every hope of abolishing malaria from rice-fields. He believed that the prevention of malaria, the improvement in health of the agriculturist and the cultivation of the land were all intimately connected and that what helped the one would improve the other. The enormous commercial value of the control or prevention of malaria in tropical countries will be appreciated by all familiar with conditions in these localities.

A USEFUL PENDULUM AND A SIMPLE WIRELESS METHOD FOR THE VELOCITY OF SOUND.

By Roy W. Kelly,
High School, Pacific Grove, Cal.

The following arrangement of a mercury contact pendulum will find a variety of uses in any physics laboratory and its description may offer several suggestions to amateur wireless operators. While all of the ideas presented are not new, the simplicity of the apparatus will appeal to busy teachers. All the parts necessary for each experiment will be found at hand in the ordinary laboratory.

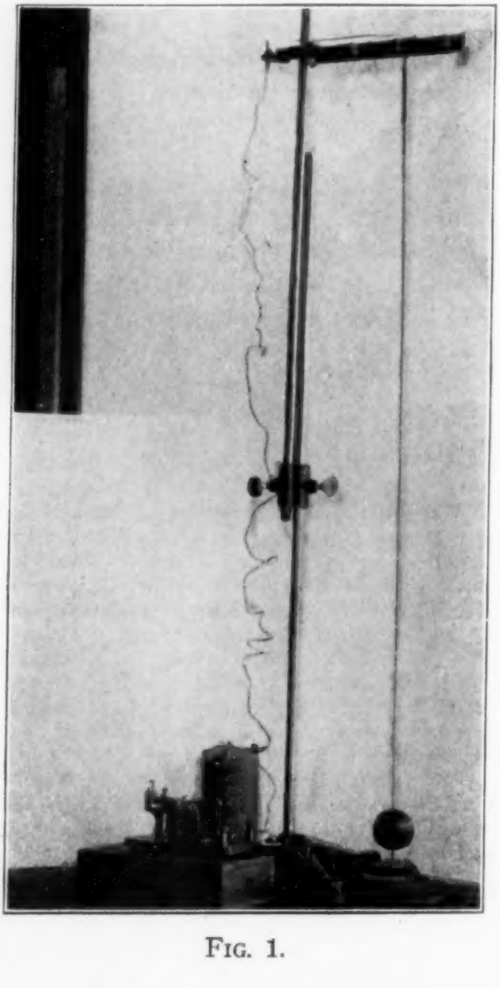


Fig. 1.

For illustrating the laws of the pendulum and finding the value of gravity, the apparatus is arranged as in figure 1. The upper part of the fine iron wire which holds the pendulum bob is fastened to a small clock spring. For all ordinary purposes, the thin flexible spring gives results equal to those obtained with a knife edge support. It can be readily clamped in any position, allowing the length of the pendulum to be quickly adjusted, and there is no danger of its being broken by constant swinging. The bob is 1.5 inch iron ball through which the wire passes to be soldered in place. Nearly an inch of the wire projects below the ball and is twisted into a spiral in order to facilitate adjusting its length in making contacts. A watch glass, filled with paraffine with a shallow trough about 3 mm. wide across the surface, holds the mercury for the contact.

As the telegraph sounder can be heard throughout the room, it gives an accurate method for counting the swings in determining the laws of the pendulum for physics classes. For short lengths, the contact can be set at the end of the arc, thus allowing double vibrations to be counted. Quicker results and a higher degree of accuracy in determining the acceleration of gravity can be secured with this simple arrangement than will be found possible with anything but expensive apparatus.

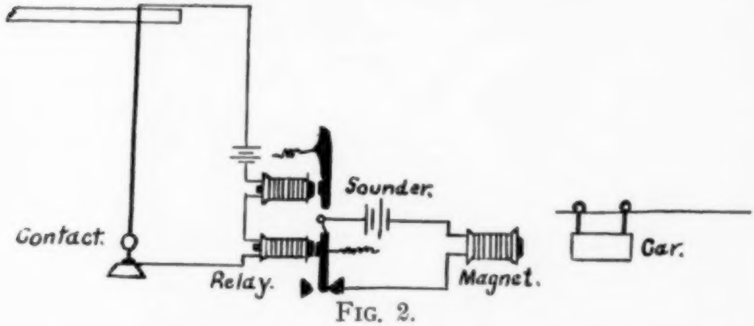


FIG. 2.

By including a telegraph relay in the circuit, the same pendulum can be used to release the car or iron ball where an inclined wire or wooden plane is used to illustrate the acceleration of falling bodies. The connections will be made clear from an examination of figure 2. The electromagnet remains in circuit except when the pendulum contact touches the mercury. The click of the sounder will coincide with the time of release of the car. Figure 3 shows a convenient method for finding how far the car has traveled at the end of any required time. The brush held

by the clamp is moved along under the trolley wire until the stroke of the bell as the car completes the circuit coincides with the click of the sounder.

For determining the velocity of sound in air, the apparatus is arranged as in figure 4. Instead of the telegraph sounder, an electric bell or gong is placed in the circuit. The pendulum is adjusted to beat seconds and a screen is placed in front of it so that the ball will be visible only at the end of the swing. A black iron ball of this size can be seen at the necessary distance against a white background. The students are instructed to move away until the stroke of the bell is heard at the same time that the pendulum reaches the end of its swing.

The elementary principles of wireless telegraphy can be illus-

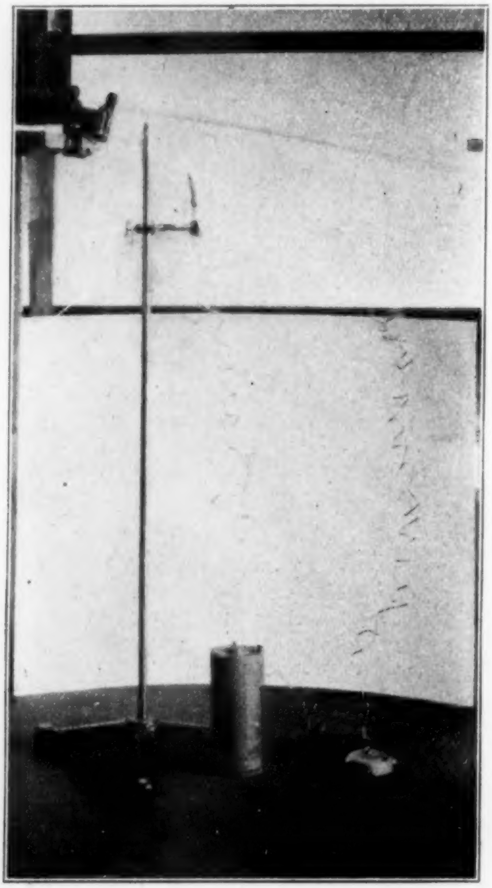


FIG. 3.

trated by the apparatus shown in figure 5. Such a pendulum is often used in physics laboratories where students in different rooms wish to take time from the same clock. The method illustrated has proved more efficient than any arrangement where the spark occurs at the point of contact with the pendulum bob. This apparatus is quickly adjusted and saves having the current constantly wasted on the primary of the induction coil. Ground can be secured by connecting to a gas or water pipe. The detector is a modified Massie's oscillaphone. It consists of two small pieces of carbon ground to a knife edge and fastened with hot sealing wax about 5 mm. apart.

A crystal of silicon or a light cambric needle is laid across the edges. If a 75 ohm telephone receiver is not at hand, two ordi-

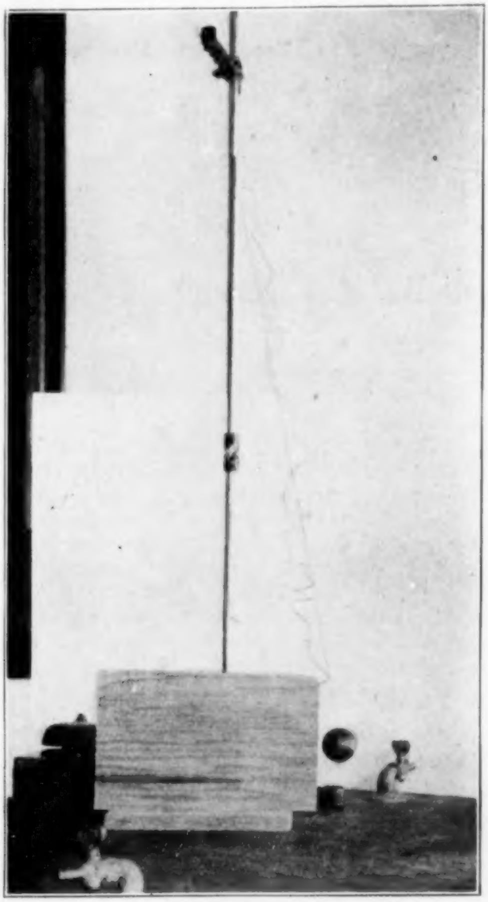


FIG. 4.

nary receivers placed in series, one for each ear, will answer nearly as well. This detector will work within a radius of several hundred feet if good "grounds" are made.

Figure 6 illustrates another modification of the pendulum for determining the velocity of sound. The pendulum is adjusted to beat half seconds. The electric gong is arranged to ring as the

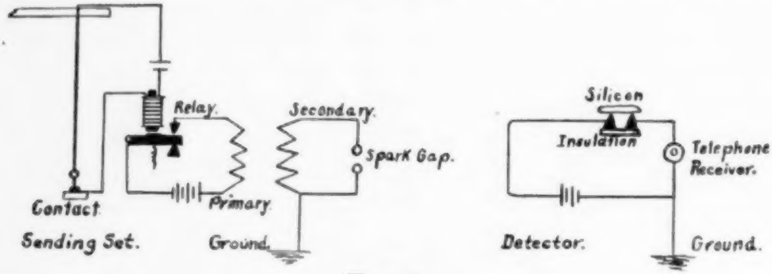


FIG. 5.

pendulum reaches one end of its swing. The other contact is so adjusted that a good spark is secured at the spark gap when the pendulum reaches the opposite end of the arc. The detector of figure 5 can be used. Ten or twelve feet of flexible wire should be attached to the receiver to permit of its being quickly moved about. The ground wire is attached to a sharp metal or carbon rod which can be thrust into the earth. The detector is placed

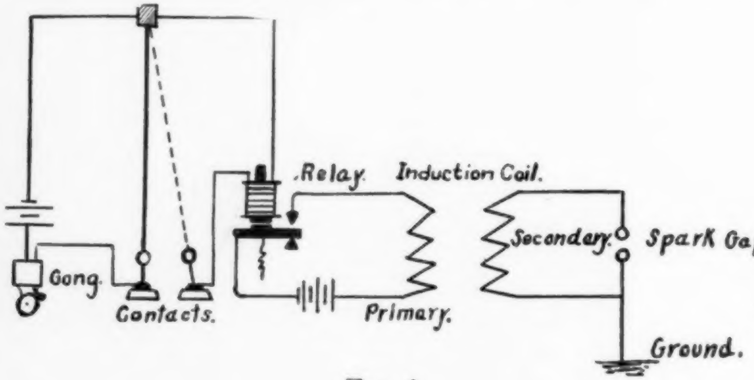


FIG. 6.

at such a distance that the sound in the receiver coincides with the stroke of the electric bell. The distance to be measured in finding the velocity of the sound wave is obviously that from the gong to the telephone receiver. For both this and the method described above, the pendulum can be conveniently placed on a table before an open window. If a complete wireless set is in

use, several interesting variations of the above experiment will suggest themselves. A portable aerial for the detector can be easily constructed if it is desirable to measure the velocity of sound over distances greater than those within reach of this simple arrangement. A couple of strands of copper wire strung across the room near the ceiling will answer for the sending aerial.

This apparatus has been in use with the writer's classes for the last two years and has given excellent results in all the experiments suggested. Very much better results have been secured by taking the experiments on the laws of the pendulum out of the individual laboratory work and presenting them to the class as a whole by using one or two pendulums of the type described. Both experiments on the velocity of sound have proved intensely interesting to students.

DEATH-RATE OF THE GERMAN EMPIRE IN 1912.

The Imperial Health Office has published the following statistics bearing on the frequency of certain important causes of death from about 400 urban communities. The number born living increased by 0.1 per cent. The increase, however, is found only among illegitimate births, which amounted to 3,209, while the number of legitimate children born was 2,577 less. The number of stillbirths also increased by 100, which was wholly attributable to the illegitimate children. On the other hand, the birth-rate has fallen from 256.6 per 10,000 in the previous year to 251.2. As a further unsatisfactory circumstance the number of stillbirths per 10,000 children born living amounted in the previous year to 322, but in 1912 to 324. The death-rate has fallen about 8.4 per cent, or 33,178, in contrast to 1911, which was very unfavorable in this respect. The death-rate sank from 16.32 to 14.60 per 1,000 of population. Especially the number of deaths in the first year of life was markedly reduced, compared with the previous year, by about 25.2 per cent. As a result the death-rate compared with 100 born living fell from 18.9 to 14.1.

As to the causes of death, an increase was observed in deaths from whooping-cough of 736, or 22.6 per cent; from measles and rötheln of 160, or 4.8 per cent; from diseases of the respiratory tract of 562, or 1.1 per cent; from murder and manslaughter of 116, or 24.5 per cent; from suicide of 443, or 6.9 per cent; and as a result of accident of 390, or 4.2 per cent. On the other hand, there was a reduction in the number of deaths from gastro-intestinal catarrh and diarrhea of 30,346, or 51.8 per cent; from typhoid of 585, or 39.3 per cent; from diphtheria and croup of 1,123, or 16.6 per cent; from scarlet fever of 259, or 9.4 per cent; from puerperal fever of 83, or 5.8 per cent, and from tuberculosis of 725, or 1.7 per cent. The number of deaths from gastro-intestinal catarrh and diarrhea in children under a year old diminished more than a half, from 49,409 in the previous year to 24,129. The excess of births over deaths rose from 9.35 in 1911, to 10.51 in the year of this report.

AN EXPERIMENT ON THE EXPANSION OF WATER.

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The object of this experiment is to let the student discover for himself the expansion curve for water between 60° and —10°, C. No claim is made to originality in the work, but the method used is so simple that it may be used conveniently in almost any laboratory, and it has given very gratifying results. The completed work lays graphically before the eye of the student the manner in which water expands and the relation existing between the apparent expansion and the real expansion. It shows clearly just how important a factor is the expansion of the glass; and it enables the student to answer for himself the question which his ordinary text-books usually do not answer, "Does water continue to expand when cooled below the freezing point, or does it contract?"

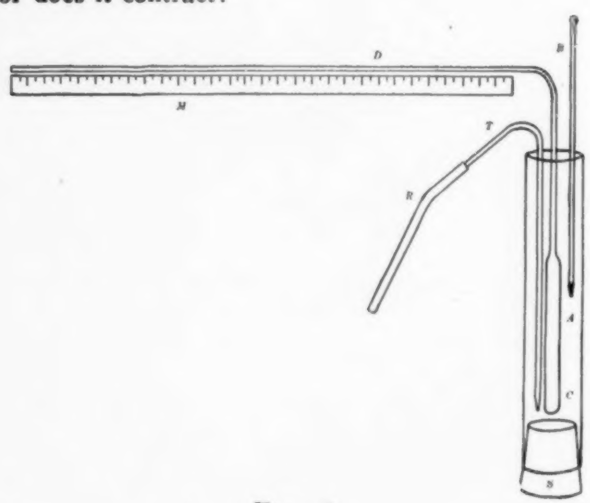

FIG. 1.

The essential parts of the apparatus are shown in figure 1. A is a bulb about 15 or 20 cm. long and about 1.5 cm. in diameter. It is sealed to a capillary tube, d, about a meter long and of about 0.5 mm. bore. The capillary may be bent at right angles above the bulb, thus bringing the atached scale, m, into a horizontal position.

The cross-sectional area of the capillary tube is determined by heating the bulb and allowing it to suck mercury into the tube as it cools. If the tube is held in a nearly horizontal posi-

tion, a column 70 or 80 cm. in length may readily be drawn into it and measured, and it is then weighed in another vessel and the area of the cross-section of the tube is computed from this data.

Next the bulb and tube are weighed dry and then filled with distilled water from which the air has recently been removed by boiling. If warm water is used the bulb may readily be filled by repeatedly heating and allowing to cool—the end of the capillary being held under water while the bulb is cooling. At room temperature the water should stand about 25 cm. from the bend in the capillary.

The tube and bulb are now weighed again to determine the amount of water being studied. It will be noted that there is some water in the capillary tube which does not experience changes in temperature with that in the bulb. The volume of this is small, however, in comparison with the volume of the bulb, and the work may be made accurate to three places without making a correction for this.

The bulb is now inserted in a water bath and brought successively to temperatures of 20°, 40°, and 60°. At these temperatures the position of the water in the tube is noted by means of the meter stick, m, which is secured to the tube.

Without changing the position of the meter stick on the tube, the water bath is replaced by an ether bath as shown in the figure. C is a glass tube having a diameter of about 1.5 inches, and about 1 foot in length. It is closed tightly at the bottom with a cork stopper. The work will be much more successful if the tube, c, is itself encased in a jacket to prevent receiving heat from the room by radiation. The boiler of an ordinary calorimeter makes a good outer jacket.

The tube, c, is now filled with ether to a point above the bulb, and air is blown in through the glass tube, t, which reaches to the bottom of the ether and is drawn down to capillary dimensions at the lower end. The best air supply is a compression tank from which the blast may be regulated by adjusting the outlet cock. Satisfactory results may be obtained by using an ordinary bellows, but a constant temperature is not so easily maintained. A thermometer, b, is inserted in the ether and should be clamped against the side of the vessel in order to prevent difficulties in reading temperatures below the freezing point. The bubbles of air serve as an efficient stirrer, and for that reason the thermometer need not be moved from place to place.

With this arrangement, readings are readily taken every two

degrees from 10° to —10°. If the apparatus is not jarred, the work may be carried this far with little danger of freezing.

After the readings are taken, a graph is plotted using temperatures as abscissas and apparent volumes as ordinates. Four degrees is taken as the temperature at which the volume in cubic centimeters is numerically equal to the weight in grams. The graph for the volume of the glass may be made by drawing a straight line through the points representing its volume at 4 and at 60. The graph for the real volumes is now plotted by simply adding the expansion of the glass bulb to the apparent expansion.

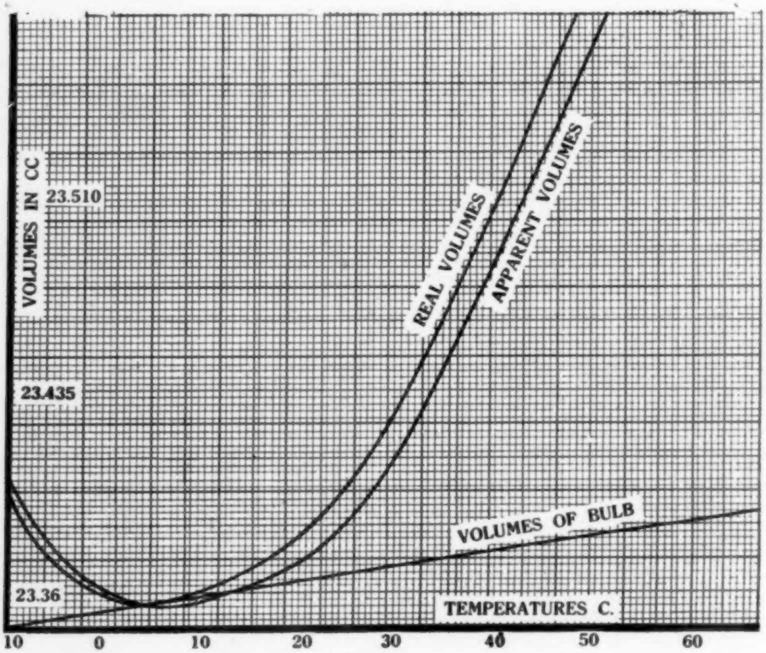

FIG. 2.

Figure 2 shows a typical example of the results attained by students. It will be noted that at 6° the apparent volume goes below the minimum value for the real volume, and that from 6° to 4° the glass contracts more rapidly than the water, making all three lines meet at 4°. As the temperature goes beolw 4° the apparent volume is, of course, greater than the real volume, and the student will notice that the real volume increases a little more rapidly as the temperature is lowered below the point of maximum density than it does as the temperature is raised above that point.

ON THE "QUANTUM" THEORY OF LIGHT.

By L. P. Sieg, Ph. D.,

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(Concluded from March issue.)

In light we find still more striking verifications. The photo electric energy can be quite satisfactorily accounted for on the basis of this theory as also can many of the characteristics of secondary cathode radiation. These two ideas I shall develop a little more fully in a later section of this paper. The apparently simple matter of line spectra has been a problem for the physicist, of no mean proportions. It is easy enough to say off hand that the lines in the spectrum of hydrogen, for example, are due to various electronic frequencies in the atom of hydrogen, when this atom is disturbed, but that is not at all satisfactory. You must know of course that an electron vibrating about the positive core of the atom, composes, with this core, a system in equilibrium. In this equilibrium state, with the electron vibrating regularly, no energy can be emitted, because by such an act, the stability of the system must be overturned. That means a change in the vibration frequency and if the emission of radiation is a continuous affair, the frequency change must be a continuous one, and there vanishes the possibility of lines in the spectrum. This past summer, Dr. Bohr, in the July and September numbers of the Philosophical Magazine, has proposed an explanation of the production of the hydrogen spectrum on the basis of the Quantum Theory, that is fascinating in the extreme. In brief Dr. Bohr pictures the single electron in the case of hydrogen vibrating around the core in one of many stable elliptical orbits. No radiation takes place except where one of these stable orbits is changing to another one. Then the radiation is of one frequency, that corresponding to the frequency in the orbit nearer the center, and the energy change in the system is this same, $\epsilon = h$ times the frequency. In this way all the series of lines at present known in the hydrogen spectrum have been accounted for and also some other lines have been predicted. Again in the subject of light we may account for fluorescence. By Stokes' law, we are told that the wave length emitted in fluorescent materials is lower in frequency than is the exciting wave. There are, however, some exceptions to this law. On the basis of the Quantum Theory

the change in radiation means a change to a lower frequency and hence to a lower energy. The energy lost has been absorbed possibly by some slow moving, non-light emitting vibrator. In this latter case we can say that the frequency is a function of the energy, rather than that the energy is a function of the frequency.

In dealing with absorption, Planck has, according to some physicists, taken a backward step in that he has found it possible and also quite desirable to consider that the absorption of energy is continuous. One reason for this assumption is that the absorption of a finite amount of energy from an external steady radiation can take place only in a finite time. If the incident energy is too weak, none can be absorbed, and the smaller the intensity of the excited vibrâtion is in comparison to an energy element ϵ, the longer the time for absorption will be. Now with increasing vibration frequency the energy element becomes very large, while we know from experience that the intensity of radiation for this large frequency becomes very small. Here then the time for absorption to take place would be far too great to agree with experiment. As a result of this especial hypothesis concerning absorption, it follows that a body, which can only emit integral numbers of whole energy elements, and absorb partial elements, can be caught at absolute zero, still in possession of some energy. While at first thought this seems absurd, it isn't so strange when we remember that we have defined absolute zero from the standpoint of molecular motion, and have not stated anything definite concerning the energy of the contents of the molecule.

All these experimental verifications from portions of physics outside those portions from, and for which Planck first outlined his theory, have been of material assistance in the spreading of his ideas. For it must be conceded that the Quantum Theory has needed these verifications, for the theory, as regards radiation phenomena has not always followed the paths of correct logic. Further, the theory puts a great burden on the atom, for there must be present all these oscillators, each with its peculiar period. I have purposely avoided the use of electron, as a synonym for oscillator, just as Planck has done throughout, for the oscillator is at present only a name for something that may have many other peculiar properties, and until we know more of it, we had best use the original word.

Before starting the last section of this paper, I should like to say a few words in connection with the universal *Wirkumgs-*

quantum, or Operating Quantity, *h.* If we have faith in Planck's theory, we must have the most wholesome respect for this quantity *h.* It occupies just as fundamental a position in energy as does the elemental charge *e* in electricity and matter. In fact, at the last meeting of the British Association, Jeans has found a strange and remarkable connection between *e* and *h,* two of the most fundamental things and probably the two fundamental things of physics. The relation is hardly definite enough for one to be called a function of the other, but the association of these two, even as tenuous as it seems, has in it possibilities that are fairly thrilling. The one primordial entity, the one universal regulator of the ceaseless ebb and flow of energy in our world of space and matter is being formed for us out of the very mists. (And yet in the face of all this romance some say that physics is really not a fit subject for high school study, except that it deal only with the practical applications and with everyday life. Please leave to the boys and girls a little of the romance.) Some have attempted to define *h* in terms of electrodynamics or mechanics, "But such an attempt," says Sommerfeld, "is as useless as a mechanical definition of Maxwell's equation." Energy does not depend upon molecular dimensions, constitution, and the like, but rather the very existence of molecules is a result of the existence of this universal operating quantity, *h.* Similarly in regard to energy. We have spoken of energy quanta, but these while fundamental are not all alike, so that energy itself cannot be conceived as being the fundamental thing in physics. Rather it is this same quantity *h,* which regulates and controls the manifestation of energy that is to be looked upon as essentially basic. In his paper before the British Association this summer, Jeans declared for the new ideas, while still holding on to the old, by stating that Maxwell's equations should in their generalized form contain both the quantities *e* and *h,* the unit respectively of electric charge and the universal operating quantity. When these two quantities are missing from the equations, then we are dealing with special simplified cases. This is just the reverse of our usual views of this matter. Now, lastly, we have spoken so much of this quantity *h,* that you may have a desire to know if it has a numerical value expressible in terms of our fundamental units of length, mass, and time. Its magnitude has been determined and proves to be the extremely small number, 6.415×10^{-27} g. cm ^{2}/sec., or to make it a little more striking, there is a decimal point followed by twenty-seven zeroes before the first

significant figure. In this connection I cannot refrain from mentioning a new set of fundamental units which Planck has suggested. To take the place of our units of length, mass, time, and temperature, he suggests the use of this quantity *h*, the speed of light, the universal gravitation constant, and the value *k* in the formula for entropy, where the entropy is a constant, *k* times the probability of the state of the body. These four units depend upon the universal law of gravitation, the propagation of light in space, and the two laws of thermodynamics. On this system of units the absolute unit of length becomes the very short distance of 3.99×10^{-33} cm; the absolute unit of time and still smaller number, 1.33×10^{-43} sec.; the unit of mass, 5.37×10^{-5} g; and the unit of temperature, 3.60×10^{32} deg. C. Had I time, I could give you sufficient reasons for believing these units better than the ones we have. But we must go on the last section, the one from which the title of this paper was taken.

Surely it does seem strange in this day for physics to ask again the world-old question—What is light?—but they are asking the question today with greater insistence than ever before. It did seem five to ten years ago as though we had a well nigh perfect picture of the mechanism of radiant energy in space. However, the persistence of investigators in the domain of experimental physics has made it necessary, at the very least, for us all to review very carefully our ideas about this matter. The particular development of this subject into the nature of radiation in space, is not a development fathered by Planck, the founder of the Quantum Theory, who has been particularly conservative on this extension of the subject. We owe perhaps more to Einstein, the founder of the relativity theory, than to any other man. It must be stated that Einstein's bold ideas are accepted in their entirety by very few physicists; nevertheless, they are remarkable enough to warrant most serious study. The whole question is, let me repeat: What constitutes light? Is it an electromagnetic wave passing out through the ether of space, or is it something quite different? According to the Quantum Theory of radiation, there is expelled from radiating matter energy in distinct bundles, indivisible for any given frequency. Now in what state does this energy go forth? We are confronted at the outset with a great difficulty in attempting to overthrow the theory of Maxwell, for we have abundant evidence from experiment that this theory does suffice. However, as I said above, there are other experiments according to which Maxwell's theory seems to

fail completely. Surely we must not rest content with any theory that cannot explain everything that falls under its domain. On the other hand we are not justified in abandoning a theory until we can get a more satisfactory substitute. First, a word concerning the much discussed ether.

I look on the word ether, as containing two meanings. One is the ether of the philosopher. If the philosopher is unhappy with space that is absolutely empty, then let him fill the space with whatever is necessary to his system of metaphysics. On the other hand the physicist has an ether which is purely a child of his own intellect. The ether of the physicist is simplicity itself: It is merely a fabricated medium that has just sufficient properties to satisfy Maxwell's equations. If we try to give it any other properties we are getting into the philosopher's domain. If for any good and sufficient reasons we feel constrained to abandon Maxwell's wave equations, just that minute the ether of the physicist ceases to exist. The other man's ether may still be there, but it has no necessary function in the propagation of radiation. Let us follow in a very brief way some of the ideas that have led some physicists to abandon Maxwell's equations, and with these equations the ether of space.

The only thoroughly satisfactory theory of the state of the ether, and in speaking of the ether I, for the remainder of this paper, shall refer to the physicist's ether, is that of Lorentz. He postulates a motionless ether. This has been tested by the famous Michelson and Morley experiment, with, however, only negative results. Arguing from this alone, and the steps of the argument are long and involved, Einstein comes to the conclusion on the principle of relativity that we come to absurd results unless we abandon the ether entirely. The absurdity comes from the conclusion, assuming Lorentz's ether and the principle of relativity, that we can imagine the ether at rest with respect to either one of two systems of co-ordinates moving through space with different velocities. This of course would be absurd. If we must abandon the ether, then the electromagnetic field constituting light is no longer a condition of a hypothetical medium, but represents rather separate images sent out by the source of light. Following this idea yet a little further, Einstein shows quite conclusively that whenever a body emits radiant energy equal to L units, it loses thereby in mass by an amount L/c^2, where c is the velocity of light. This further strengthens his feeling that light is not a condition of a medium, but rather that

it is something that has as independent an existence as has matter itself. But we need not go to such highly speculative sources. We have some common laboratory experiments that cause us sufficient food for thought. Why, for example, is the photoelectric potential independent of intensity? Let me illustrate in a manner, which though crude, will perhaps be illuminating. Light a candle and place an insulated sheet of zinc, say one square centimeter in cross section at a distance of one meter. The zinc attains practically instantly a certain positive charge, due to the liberation of the electrons from its surface. Repeat the experiment with the zinc plate held further away. Again we get the same potential on the zinc plate, although the intensity of the light on the plate is now much less. If light goes out from the candle in spherical waves, surely the energy falling on a certain area becomes less and less, the farther away the plate is held. Campbell in his recent book on Modern Electrical Theory has calculated that with a source of light of a given intensity a certain photoelectric potential should be acquired, on the basis of the electromagnetic theory only at the expiration of one-quarter of an hour, because that time would be necessary, if the plate were perfectly absorbing to accumulate enough energy to expel the electrons, and thus give the plate the potential, that it gets in reality almost instantly. Now, if light is sent out by the candle in quanta or bundles, then no matter how far away the plate is, within reason of course, it will be bombarded with these quanta. At any rate it will either show the full potential or none; it will not build up slowly. Again we have X-rays originating from the starting or the stopping of cathode rays. These X-rays fall on matter under proper circumstances, and cause thereby the emission of secondary cathode rays, which latter rays have energy of the same order of magnitude as those of the primary cathode rays. Surely this could not be if the waves constituting the X-rays should spread out uniformly in all directions, for that would lead to a contradiction of the law of conservation of energy. It certainly looks like a bombardment of compact bundles of energy, and not like the uniform spreading out of waves. If we could get a source of light feeble enough in energy it would emit explosively one or more quanta at a time in random directions like the shooting of stars from a Roman candle in the hands of an extremely irresponsible person. For a bright light, multiply this millions of times. This surely is not the picture most of us form of the passing out of radiant energy.

Once more let me ask you to form a picture of the enclosed space containing impermeable walls, and radiating matter. It is in connection with this special case that Einstein has exhibited what seems to me his most brilliant reasoning. Grant that the radiant energy is expelled from the matter in quanta, and assume for the once that the radiation is continuous. Imagine a small plane, perfectly reflecting surface inside the walls. This surface meets irregular blows from the molecules, supposed to be very sparse, and as a result of these irregular blows it will be moved, just as in the case of the Brownian movement. The radiation pressure on the other hand is supposed to be perfectly continuous and equal on both sides of the plate, as long as the plate is. stationary. However, when the plate moves it must, in accordance with Doppler's Principle, experience a radiation friction which causes it to be retarded, but this in turn tends to convert the molecular energy into radiation energy. The result will evidently be that all the energy will ultimately become radiation energy, as in the case of Jeans' theory, while the matter will lose its heat energy entirely. The only escape from this is to assume that the radiation is as discontinuous as are the molecular impacts, and the average kinetic energy of vibration of the plate equals one-third part of the kinetic energy of a monotomic gas molecule at this temperature. Continuing the argument Einstein arrives at an expression for the momentum of the plate which consists of two terms; one the standard expression based on electrodynamics, and the other term based on Planck's energy quantum. The second term for the case when the temperature is 1700 degrees and the wave length that of sodium light is 65,000,000 times as great as the electrodynamic expression; so much larger, in fact, that the latter can be neglected in comparison with the former. Lastly, quoting from Einstein, "If we should suppose that diffraction and interference phenomena were unknown, but that one knows the average value of the irregular variation in light pressure, where n would be a parameter determining color of unknown meaning, then who would ever build up the wave theory?" However, we can think of the electromagnetic field as collected around singular points; just as in the electron theory, the electrostatic field is built up. When radiation is not sparse, the resultant condition of the field will be the same as on the wave theory, and there is no denying that the wave theory does work admirably for elementary discussion of light problems.

In closing this paper let me quote, this time from Planck. "The Quantum Theory is just as well founded, or even better so than the old electrodynamics. Only some do not realize the limits of the latter. Years and tens of years are necessary, with much experiment. He who would today devote his efforts to the Quantum Theory, must for a while be satisfied with the consciousness that the full development of the present labor will not be reached until a later generation."

And now in conclusion, I feel constrained, in view of the fact that many of you are engaged in teaching first courses in physics, to attempt a suggestion as to the attitude a teacher, say in a secondary school, should take in respect to the subject of radiation, and particularly to the subject of light. Many of you have no doubt thought this through. Shall you teach this theory in your classes; in whole, or in part, or not at all? Shall you abandon the electromagnetic theory? If my advice is of any worth to you, I offer the suggestion that for the present at least you cling to the wave theory and the electromagnetic idea of a wave. This theory represents most of the facts admirably, and these other phenomena can be treated, if they come up, as separate matters. On the other hand, I trust that none of us present will ever be satisfied with a stationary position in this regard, but that for our own personal development we shall always be keen, not only to follow the shaping of new ideas, but also to lend our best efforts in the strenuous labor of widening the boundaries of this narrow space that we claim to be the domain of human knowledge.

STABILITY AT LAST.

One thing that every botanist desires is stability in plant names. Some fifteen or twenty years ago, we were told that to get stability, all we had to do was to follow the lead of certain advocates of an "American Code" for naming plants. A good many students who thought they could forecast the future to some extent were dubious about such methods of obtaining stability but others showed their confidence in the new movement by using the nomenclature in the books they issued. The monumental "Illustrated Flora" used this nomenclature and now that the second edition has appeared we can see just how this stability works. We find that during the time that elapsed between the first and second editions, 136 genera and several hundred species have had a change of name. This ought to settle those obstreperous individuals who keep repeating that there is no stability under the American Code. If changing so many plant names isn't stability, what is it?—*American Botanist.*

"EVOLUTION" IN THE HIGH SCHOOL.

By Oran L. Raber,
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It has been the experience of all ages and institutions that perfect indifference to existing environmental conditions is impossible. The reaction is either a positive or a negative one. Advance or the lack of advance, which, in comparison to the progress of the similar units which surround it, means retreat, is inevitable.

It is thus with our American high school of the twentieth century. Within the last twenty years a great flood of ideas has swept down upon it and its leaders, and they have been called upon to decide whether they wish to resist the sweep of the current which would take them from the barren highlands of the past to the fertile plains below. Many are still holding out, but it is only a matter of time until their foundations of prejudice will be weakened, and our ideas of propriety in education will then receive a new impetus.

There are many illustrations to bear out this point, but the one with which this paper intends primarily to deal is that of evolution. It has now been about a half century since the principles underlying organic evolution were discovered and formulated into a definite theory. Additions have been made from time to time and new facts in all branches of science have been found which validate the theory, so that at the present time, in the words of a recent issue of *The Independent,* "no thoroughly educated inindividual now doubts the correctness of these scientifically established ideas." Nevertheless outside of our very largest cities, very great care is necessary in the presentation of biological subjects. At times it even becomes almost necessary to give the wrong interpretation of the fact. If asked, for instance, by a pupil, "Why do we have those little pointed notches in our ears," what are you going to say? Will you tell him the truth as far as you know it, or will you tell him a semi-truth and say, "Oh, that is just natural?" Too frequently to suit either the teacher or the pupil, the latter is the alternative chosen. Why is this, and what is the remedy?

I believe the fault lies primarily with the parents in the home. The pupils are eager enough for the truth, but the parents are not eager to have the pupils obtain it. The reason for this is not hard to discover. The parents, i. e., most of them, of the present generation of high school children, were taught under the old

regime. Science was a very minor part of the curriculum of their time, and much of that small part was pseudo-science. The vast accumulation of scientific ideas of the last twenty years has been beyond them, and their lives have been shaped by a different mould. To them Darwin, evolution, and natural selection are synonyms for Satan, sin, and eternal damnation. They interpret nature as themselves—both unchanging. They have lived long if not always well without such "crass nonsense," and have perhaps accumulated small fortunes. Scientists who promulgate such ideas are generally poor. They immediately become victims of the old fallacy of "post hoc, ergo, propter hoc" and see in the poverty of scientists a judgment for their wickedness. Tom and Mary shall never be permitted to play with such intellectual fire.

How may this present condition of affairs be remedied? All teachers and students of science know that evolution permeates and saturates all modern science and especially biology and geology, and that to teach science without bringing in this idea of evolution is like teaching algebra without factoring, language without declension, and history without chronology. The question we science teachers frequently have to face is how to teach a subject of the twentieth century which many of the parents of the students are opposed to. How can we impart to the student that idea of change and instability which permeates modern thought? How can we show the parent that a law-abiding change is as fundamental as a law-abiding permanency?

In the first place, the parent should be shown the true meaning of evolution and its relation to progress. Most parents think that evolution can be summed up in the words "man from monkey" and that is all there is to it. They have either not tried to keep informed of the advance of science, or have failed to understand what they have read because of a poor background of knowledge. As an illustration of this latter case let me cite the following example. Once in the town in which I happened to be teaching I was introduced to a lady who was indeed a very bright woman, read much, and tried to keep herself informed on topics of general interest. She commenced the conversation by saying, "I hear that you are a believer in evolution?" "Why, yes," I replied, "My experience and study have proved to my own satisfaction the validity of evolution." "Well, young man," she continued, "I tell you there's nothing in it—nothing at all. I have read all that Darwin, Spencer, Huxley, and all those other fellows ever wrote about the matter and I don't believe a word of

it. Now, for instance, Darwin said that babies had gills like a fish when they were young. My father was a doctor and saw hundreds of babies come into this world, and never in all his practice did he see one with gills like a fish. No, sir, there's nothing in it." We here see the need of instruction for the parents. Parent-teacher associations have been organized in many places throughout the country, and I know of no better place to teach the parents what we teach the pupils than here. I believe as much good can be done by discussing the subject matter of the school at these meetings as can be done by a discussion of "Home Study," "Clothes for School Children," and the other fifty-seven varieties of subjects of like nature which take up the most of the time at these meetings without leading to any valuable conclusions. Here should be the place to present such matters to the patrons. Here *they* can be educated, and then we can go ahead with the pupils. Here the patrons can have their fears quelled; here they can be shown that a belief in evolution does not necessarily result in atheism or agnosticism; and here they can obtain answers to questions that perhaps they have long wanted to ask.

The teaching of evolution should in itself be an evolution—a gradual development and unfolding of the subject. The question immediately comes up of how far to go and what to include. Someone asks, "Would you teach the anthropoidal descent of man, to high school pupils?" I should answer, "That depends." If the class was a senior class and the opportunity presented itself, I certainly should. If some questions regarding the matter were asked by freshmen, I should answer them as well as I could. Any truth which a student can understand even imperfectly should be imparted to him at the time that he feels a need for that truth. (That statement may sound trite but many teachers fail to apply the principle underlying it.) I have always felt that high school science as well as any other subject should be a preparation for life and not necessarily for a university. Most of our pupils never get beyond the high school. If all of them went to college, some of these matters could undoubtedly be postponed until then with *more* profit, but the majority of our students, as is well known, go out into real life and not into college life, and if they are to ever have these phases of evolution put before them, now is the time. True, they will not understand as clearly as we should like to have them, and some of them may even get slightly erroneous ideas which they will have to correct by later reading,

but who dares to doubt that a semi-truth leading to complete truth is better than total ignorance? The development of knowledge has always been after this manner.

Again someone may ask, "Should one try to harmonize the previous Biblical knowledge of the high school pupil and his scientific knowledge?" Because our Sunday school teachers of the youth have not been versed in science, I suppose it is our duty, if called upon, to correct for them some of the ideas which previous training in the Sunday school or home has led them, and to show the pupil as clearly as we can that the story of Nature and its Mossaic interpretation are stories of the same phenomena related in a different manner, certain religious and scientific fanatical enthusiasts to the contrary. One year I made the following experiment: After numerous questions had been asked (as they generally are) I went through the first chapter of Genesis verse by verse, telling the scientific story of the facts narrated there at the same time. Then I showed the class how the stories agreed. There was, of course, much discussion and a few pupils were not very well satisfied with certain parts of the comparison. In that respect the recitation was a failure as far as those few pupils were concerned, but I believe the discussion itself—the stirring up of their gray matter—justified the time spent. We must learn to not always expect immediate results. We well remember how our dear English teachers used to make us learn poetry by the foot when we never understood a word of it, but they knew that as the years passed on the words would remain with us and later the meaning would come. The same principle holds in other subjects—and in this one. We teachers may give some ideas which may not be entirely comprehended now, but which will be later. Where will the pupil be, if he does not have that basic idea upon which to base his further experience?

Evolution—that all pervading idea—must come sooner or later into our public schools if it is ever to be incorporated into the public thought, and we teachers of science must do our share if the opening century is to have the intelligent public it so much needs. Teach the parents where necessary, and teach the pupils. Science means much to the public; let it mean more.

A PRACTICAL COURSE IN BIOLOGY.

By George C. Wood,

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Requests from hundreds of teachers—representing a majority of the states of the Union, and ranging over a period of over four years—for copies of the course of study used in this school have been so frequent and insistent that it seems best to publish the course in full. In several previous issues of this periodical, the writer has laid down some fundamentals which he believes important in the teaching of Practical Biology.

The course here fully outlined is not a complete and final exposition of these fundamentals. The reason for this is obvious when one considers that the course was, originally, the work of three men belonging to a department of eight persons, all possessing marked individual and more or less set views on the way biology should be taught. The battle was, has been and is being waged between the structuralists and functionists. The course here presented is a compromise. It is not fixed, nor is it final. It is changed as we grow by experience including success and failure. No course of study can be final today. When that stage comes, education will have begun to lose its power as a factor in social progress.

This course is adapted to cover the first year of the high school course, consisting of approximately 36 weeks of actual instruction of five periods a week. Laboratory work is done at the convenience of the teacher as far as the stated time is concerned. The time to be occupied by plant biology is 12 weeks; by animal biology, 9 weeks; by human biology, 15 weeks. The first half year's work ends at the conclusion of topic L on Insects. This plan tends to break down the plant, animal and human distinctions in the subject and give us a unit course.

The method and point of attack is obvious. The fundamental needs of living things are used as a basis of the work. These needs are developed in the work on plants; tested in the work on animals and given a practical application in the work on the human body. Function precedes structure; only enough structure is given in order that function may be understood; the common things are dwelt upon; hygiene is strongly emphasized; some idea of evolution is given; the whole course tends to become practical.

The philosophy of the course here outlined is given at length in the March, 1913 and January, 1914 issues of this magazine. It is here presented in full with the sincere hope that it may be of some practical use to the teacher of biology in the secondary school.

I. Plant Biology.

A. *Study of the Plant as a Whole.*

1. Essential parts.
2. Functions of essential parts.
3. Life cycle.
4. Dependence of plant upon soil, air, moisture, heat, light, etc.

B. *Sources and Composition of Living Things.*

1. Origin of soil. Rocks (inorganic); addition of decayed plants and animals (organic).
2. Kinds of soil. Humus, loam, sand, clay, etc.; value of each to plant life.
3. Chemical elements and compounds in soil and air. Discussion of the general properties of carbon, oxygen, hydrogen, nitrogen, carbon dioxide, water, nitrates, sulphates, phosphates, as materials for food and tissue building.
4. Importance of oxygen to living things.
   (a) Experiment to show oxidation and its results (heat, CO_2, water).
   (b) Experiment to produce CO_2 in germinating seeds. Identity of process and results in plant and animal.

C. *The Young Plant.* (Seeds and Seedlings.)

1. Function of seed-reproduction.
2. Conditions necessary for germination.
3. Gross structure.
   (a) Seed coats and uses.
   (b) Embryo parts (shoot, root, seed, leaf) and uses.
   (c) Endosperm (when present).
4. Demonstrations.
   (a) Nutrients.
   (b) Food tests.
   (c) Digestion of starch.
5. Drawings. Bean seed showing opened embryo.
6. Discussion of important changes in the various parts of the embryo during germination.
7. Discussion of seed selection by the farmer and horticulturist.
8. Economic importance of seeds as food, medicine, stimulants; manufactures and arts.

D. *Roots.*

1. Functions of roots, as
   (a) Holdfasts.
   (b) Absorbers of raw materials.
   (c) Conductors of liquids.
   (d) Storers of food.
   Demonstration of a root hair.
2. Gross structure—Epidermis, cortex, central cylinder, ducts, rootlets and root hairs demonstrated. Function of each. Development of idea of the *plant cell.*
3. Method of securing food.
   (a) Sources of raw materials—air, soil, water, other plants (parasitic).
   (b) Substances absorbed by root hairs.
   (c) Experiment on osmosis and application to the work of root hairs.
4. Food conduction illustrated by an experiment to show the rise of red ink in a carrot or parsnip.

5. Economic importance of roots as food, condiments, medicines, beverages, and in nitrogen fixation.

E. *Stems.*

1. Function of stems.
    (a) Support. Monocot—rind. Dicot—bark wood.
    (b) Conduction. Monocot—ducts. Dicot—sieve tubes, ducts.
    (c) Food storage. Monocot—pith. Dicot—medullary rays, pith, sap wood.
2. Gross structure.
    (a) Monocotyledon—rind, pith, ducts.
    (b) Dicotyledon—bark (sieve tubes), cambium, wood (ducts), medullary rays, pith.
3. Drawings of gross structure of the longtitudinal or cross section of a corn stem and the external view and cross section of a horse chestnut twig.
4. Economic importance of stems as food, medicine, in manufacture and arts. By-products. Value of five commonly used woods (oak, pine, maple, cherry, hickory).
5. Care of trees.
    (a) Pruning. Use to plant.
    (b) Protection against animals, insects and disease.
    (c) Conditions for proper growth (space, light, soil, water).
    (d) Civic value (beauty, equalizer of temperature, bird homes, enhancement of property value).
6. Methods of propagation.
    (a) Grafting and budding (apple, etc.). Purpose and necessary conditions.
    (b) Stem cuttings (geranium).
    (c) Underground stems (potato).

F. *Leaves.*

1. Function of leaf-food manufacture.
2. Substances taken into leaf from air (O; CO_2); from the stem H_2O and dissolved materials).
3. Processes carried on by leaf. Discussion of starch making. Use of sugar and starch by the plant. Digestion defined and illustrated by seeds and seedlings.
4. Other processes—respiration and transpiration.
5. Demonstration: Liberation of H_2O by the leaf.
6. Structure of leaf and use of parts—veins, epidermis, stomata, chlorophyll.
7. Drawing of leaf cross section from microscopic slide, chart or book aided by discussion.
8. Drawing of stoma, and adjacent cells in same manner as in (9).
9. Discussion of the effect of light on carbohydrate manufacture and leaf movements. Demonstration. Window plant's response to light.
10. Economic importance of leaves as food, stimulants, narcotics, soil enrichers, decoration.

G. *Flowers.*

1. Function—seed formation.
2. Gross structure and use of parts.
    (a) Essential parts (stamens and pistils).
    (b) Additional parts (sepals and petals).
3. Drawings. Flower (entire or in parts). Suggested forms: Tulip or sweet pea or gladiolus.

4. Seed formation.
   Step 1. Pollination.
   - (a) Kinds (cross—self).
   - (b) Agents (wind, insect, man).
   - (c) Methods (natural, artificial).
   - (d) Prevention of self-pollination (imperfect flowers, irregularity, unequal maturing of essential parts.
   - (e) Modification to use agents of dispersal (pollen, nectar, odor, color, etc.).

   Step 2. Fertilization.
   - (a) Essential conditions. Union of essential parts of ovule and pollen.
   - (b) Location and cellular nature of pollen and ovule.

   Step 3. Changes following fertilization.
   - (a) Loss of parts—stamens and petals.
   - (b) Enlargement of parts. Cell division and development of embryo.
   - (c) Storage of food.
   - (d) Comparison of seed and its formation to mother and offspring.
5. Economic importance of flowers as food, medicine, perfume, condiment, decoration.

H. *Fruits.*

1. Function: Seed protection and seed distribution.
2. Gross structure and use of parts. Ovary, seed, connected parts.
3. Types of fruits: Dry—pea; fleshy—apple.
4. Necessity of dispersal.
   - (a) Natural—by agents and adaptations.
   - (b) Artificial—by man. Purpose and results.
5. Drawing of longitudinal section of apple, or pea fruit, to show origin of parts in the flower.
6. Production of new varieties and increase of yield by hybridizing, selection and grafting. Work of Luther Burbank and others.
7. Economic importance of fruits as food, medicine, extracts, etc.

I. *Conservation of Natural Resources.*

1. Wealth of the nation depends upon natural resources composed of water, minerals, soil, animals and vegetation (forests, crops, by-products).
2. Uses of the forest: Lumber, soil preserver, water reservoir, temperature equalizer, soil enricher, bird shelter, food, medicine, beauty.
3. Dangers to forests: Fires, storms, insects, disease, man, lumberman.
4. Conservation by city, state and nation.
   - (a) Methods used against dangers to the forests.
   - (b) National parks, reserves, nurseries, parks.
   - (c) Co-operation of the individual with city-park departments, state and national bureaus.
   - (d) Reclamation. Purpose and results.
   - (e) Crops.
     - (1.) Value of country (10 leading crops).
     - (2.) Dangers to crops (insects and disease).
     - (3.) Assistance of state and national departments of agriculture.

Illustrated lecture on forestry or visit to museum suggested (optional).

J. *Discussion and Review of the Fundamentals of Plant Biology and the Development of the Great Needs of Plants.*

1. Need of food.
2. Need of air.
3. Need of reproduction.
4. Need of protection with special emphasis upon the inadequacy of natural means to protect plants and the consequent development of conservation.

II. ANIMAL BIOLOGY.

K. *Introduction.*

1. Relation of animals to wealth of the nation.
   (a) Useful.
      (1.) Direct.
      (2.) Indirect.
   (b) Harmful, affecting agriculture and producing disease.
2. Listing of common animals affecting the wealth of the nation.
3. Chief groups of the animal kingdom.

Sub-Kingdom—Invertebrates.
- Branch 1. Protozoa (unicellular animals)—amoeba.
- Branch 2. Porifera (pore bearing animals)—sponges.
- Branch 3. Coelenterata (hollow stomached animals)—jelly fish, corals.
- Branch 4. Echinodermata (spiny skinned animals)—star fishes.
- Branch 5. Vermes—worms.
- Branch 6. Mollusca (soft bodied animals)—clams, oysters, snails.
- Branch 7. Arthropoda (jointed legged animals).
  - Class I. Crustacea—crabs, lobsters, etc.
  - Class II. Myriapoda—centipeds, etc.
  - Class III. Arachnida—spiders.
  - Class IV. Hexapoda—insects.

Sub-Kingdom—Vertebrates.
- Branch 1. Chordata.
  - Class I. Pisces—fishes.
  - Class II. Amphibia—frog.
  - Class III. Reptilia—snake, lizard, turtle, alligator.
  - Class IV. Aves—birds.
  - Class V. Mammalia—dog, rabbit, horse, man.

L. *Grasshopper as a Type of Biting Insect.*

1. Reasons for study of this form as developed from the general survey of animal kingdom.
2. Conditions necessary for life with emphasis on *food-getting.*
   (a) Need of food.
      (1.) Kinds of food. Effect upon crops.
      (2.) Methods of obtaining food.
      (3.) Adaptations of mouth parts for feeding.
      (4.) Drawing of side view of grasshopper.
   (b) Need of air.
      (1.) Method of breathing (respiration).
      (2.) Adaptation for breathing, trachea, spiracles.
      (3.) Demonstration of trachea.
   (c) Need of reproduction.
      (1.) Life cycle (incomplete metamorphosis).
         Fertilization, egg laying, immature (nymph), adult.

(2.) Life cycle of one other insect (complete metamorphosis). Fertilization, egg laying, larva, pupa, adult.
(d) Need of protection.
(1.) Defensive. Coloration, locomotion, body covering, etc.
(2.) Offensive—none.
(e) Economic importance of insects.
(1.) Useful—pollination, honey, insect destroyers, silk.
(2.) Harmful—crop destruction, fabric destruction and carriers of disease.
(3.) Methods of destroying injurious insects. Natural (protection of birds, other insects, etc.). Artificial (sprays for biting, emulsions for sucking).
(4.) Co-operation of the state and national departments of agriculture.
(5.) Recognition of 10 common insects (optional).

M. *Perch as a Type of Fish.*

1. Conditions necessary for life with emphasis on *respiration.*
(a) Need of food.
(1.) Kinds of food.
(2.) Methods of obtaining food. Structures adapted for this purpose (paired and unpaired fins). Relation to escape and higher animals.
(3.) Methods of feeding. Structures and their relation to the struggle for existence.
(4.) Drawing: Side view of fish.
(b) Need of air.
(1.) Method of breathing.
(2.) Structures for breathing. Gills, structure and protection. Adaptation for obtaining maximum amount of oxygen.
(3.) Drawing: One gill (removed).
(c) Need of reproduction.
(1.) Life cycle: Egg-laying, fertilization (external), young, adult. Number of eggs contrasted with lack of care by mother.
(d) Need of protection.
(1.) Defensive—color, scales, spines, fins, etc.
(2.) Offensive: Teeth and spines (in some cases).
(e) Economic importance of fishes.
(1.) Useful—food, fertilizer, by-products.
(2.) Harmful—destruction of food fishes.
(3.) Laws of protection (open and closed seasons). Hatcheries. Work of state and federal governments.
(4.) Recognition of 10 food fishes on field trip to aquarium (optional).

N. *Robin as a Type of Bird.*

1. Conditions necessary for life with emphasis upon *protection.*
(a) Need of food.
(1.) Kinds of food.
(2.) Method of obtaining food.
(3.) Method of feeding (bill, claws).
(b) Need of air.
(1.) Method of breathing.
(2.) Structures for breathing (nostrils, wind pipe, lungs).
(c) Need of reproduction.
(1.) Life cycle. Fertilization (internal), egg-laying (number,

incubation, protection), young (helpless), adult. Decrease in number of offspring.
(2.) Instincts: Song, mating, nesting, care of young, migration.
(d) Need of protection.
(1.) Defensive: Bills, claws, special senses, color, etc.
(2.) Offensive: Claws, bills.
(e) Economic importance of birds.
(1.) Useful.
(a) Direct: Meat, eggs, feathers.
(b) Indirect: Destroyers of insects, rodents; produce guano; song, beauty.
(2.) Harmful: Destroys fruits, seeds and trees.
(3.) Protective measures.
(a) Laws—open and closed seasons—shooting permits—tariff law—McLean migrating bird law, etc.
(b) Reservations, hatcheries.
(c) Audubon societies.
(d) Literature and public opinion.
(4.) Drawings of the bills and feet of three birds showing widely different structural adaptations. Recognition of 10 common birds from trip to museum (optional).

O. *Rat as a Type of Mammal.*

1. Conditions necessary for life with emphasis upon *reproduction.*
(a) Need of food.
(1.) Kinds of food.
(2.) Methods of obtaining food.
(3.) Methods of feeding: Split lip, incisors.
(4.) A comparative study of the dentition of a rodent, a herbivore (cow), a carnivore (cat) and an omnivore (man). Drawings (optional).
(b) Need of air.
(1.) Method of breathing.
(2.) Structures for breathing (nostrils, trachea, lungs) demonstrated from charts or mounted prepared specimen.
(c) Need of reproduction.
(1.) Life cycle. Fertilization (internal), development of embryo attached to placenta and birth; young (helpless); adult. Decrease in number of young. Increase in attendant dangers to mother.
(d) Need of protection.
(1.) Defensive in ungulates, carnivores and herbivores.
(2.) Offensive in ungulates, carnivores and herbivores.
(e) Economic importance of mammals.
(1.) Useful: Food, medicines, clothing, draught animals, by-products, etc.
(2.) Harmful: Destroyers of crops, trees, useful animals, carriers of disease, etc.
(3.) Protective measures.
(a) Laws, open and closed seasons, etc.
(b) Reservations, etc.
(c) Societies and literature.

P. *Parasites.*

1. Important kinds: External (aphid, mosquito); internal (malaria, hook worm).

2. Animal parasites on plants (boll weevil, aphids, etc.)
3. Animal parasites on animals: Cattle (anthrax); man (hook worm, trichina, tape worm); protozoa (malaria).
4. Characteristics of parasites (internal) in general—atrophy of parts; great number of eggs; simple body structure.
5. Demonstration of living protozoa (paramoecium) by projectoscope to show simple body structure, fulfilling all needs of living things as an introduction to human biology.

Q. *Evolution of Animals.* (Showing increasing complexity from protozoa to man).

I. Invertebrates.
1. Protozoa (one celled)—no organs.
2. Sponges (many celled)—no organs.
3. Jelly fishes (many cells)—primitive organs.
4. Worms (many celled)—no well developed appendages.
5. Lobsters (many celled)—well developed appendages.
6. Insects (many celled)—well developed appendages.

II. Vertebrates.
1. Fishes (cold blooded—many celled)—well developed organs.
2. Frogs (cold blooded—many celled)—well developed organs.
3. Reptiles (cold blooded—many celled)—well developed organs.
4. Birds (warm blooded—many celled)—complex organs, instincts.
5. Man (warm blooded—many celled)—complex organs, intelligence. Evolution from water to land; from land to air.

III. Human Biology.

1. Human body a cell aggregate fulfilling same needs as plants and protozoa.
2. Vital needs of living things.
   (a) Digestion (circulation, excretion, assimilation).
   (b) Respiration.
   (c) Reproduction.
   (d) Protection.

R. *Need of Food.*
1. Food as producer of heat and power.
2. Sources: Vegetable, animal, inorganic materials.
3. Composition.
   (a) Nutrients (carbohydrates, fats, oils, protein) in common foods.
   (b) Value of each to the body.
   (c) Food preparation. Principles involved.
   (d) Food economy: In purchase; in daily use in relation to occupation and climate.
   (e) Food adulterants: Harmless; harmful.
   (f) Food and drug laws to prevent
      (1.) Adulteration.
      (2.) Misbranding.
      (3.) Reduced weight.
   (g) Co-operation of nation, state and city in enforcing food laws, inspection, transportation and refrigeration of meats, milk and vegetables.

S. *Digestion of Food.*
1. Necessity for digestion of food.
2. Apparatus for digesting food.
   (a) In mouth—teeth—kinds, number, functions, sets, structure.

hygiene; tongue—three uses; salivary glands—number, position, contents, use.

Experiment on digestion of starch.

(b) In throat—pharynx, tonsils, eustachian tubes, epiglottis, hygiene, no digestion.

(c) In stomach—shape, structure, muscle layers, mucous layer valves, gastric juices.

Experiment on digestion of proteid.

(d) In small intestine—muscle layers, villi, location, structure, number. Osmosis in relation to increased surface by folds and villi.

(e) Glands—liver—size, location, three functions (demonstration—bile and oil emulsion); pancreas—location, function, ferments.

(f) In large intestine—reservoir. Hygiene of intestines, regularity of habits, constipation, auto-intoxication, alcohol, narcotics.

(g) Common diseases of throat and intestines.

(h) Antidotes for common poisons (carbolic acid, arsenic, iodine, etc.).

T. *Circulation of Food.*

1. Need of circulation for supplying nutrients to the cells of the body.
2. Apparatus of circulation: Blood, heart, arteries, veins, capillaries, lymph.
   (a) Blood structure.
      (1.) Red corpuscles—use, number, structure, origin, destruction, hygiene in relation to (1) food, (2) air, (3) narcotics, (4) stimulants, (5) sleep, (6) exercise.
      (2.) White corpuscles—use, number, origin, destruction.
      (3.) Plasma—uses, structure, clot.
      (4.) Blood diseases,
   (b) Heart—position, size, protection, vessels, valves.
   (c) Blood vessels.
      (1.) Arteries—internal position, coats, pulse, use, reason for going to each vital organ.
      (2.) Veins—external position, function, valves, portal vein.
      (3.) Capillaries—size, position, use in relation to structure. Demonstration of blood in frog's foot.
      (4.) Lymph—origin, use, composition (outline only).
3. Hygiene.
   (a) Bleeding, fainting, first aid, dangers of exposed wounds.
   (b) Distinction between food, stimulant, narcotic, poison.
   (c) Moral, social, physiological and economic arguments against use of alcohol.
   (d) Patent medicines.

U. *Need of Air.*

1. Purpose of oxygen to produce oxidation and release energy.
2. Apparatus for carrying oxygen to cells of the body.
   (a) Lungs—size, position, protection, respiratory movements. Adaptations of mouth, nose, trachea. Ribs—muscles—diaphram.
   (b) Skin.
3. Composition of air. Gases. Relative quantities.
4. Changes in lungs during a respiratory movement (transfer of CO_2 and O by osmosis).

5. Oxidation—where carried on. By-products.
6. Hygiene. Respiration in relation to
   (a) Dust and bacteria.
   (b) Manner of breathing (shallow, deep).
   (c) Occupations and disease.
   (d) Ventilation.

V. *Excretion.*

1. Need of excretion.
2. Organs of excretion—lungs, kidneys, skin.
3. Hygiene—right habits, bathing, clothing, in relation to seasonal changes. Diseases of excretory organs.

W. *Need of Protection.*

1. Skeleton.
   (a) Purpose—protection for vital organs and attachment for muscles.
   (b) Structure—trunk, spinal column, ribs, girdles—appendages.
   (c) Composition of bones—mineral, animal matter, articulation, maximum strength in relation to minimum weight.
   (d) Hygiene: Fractures in young and old. First aid. Exercise. Deformity.
2. Muscles.
   (a) Kinds—voluntary and involuntary.
   (b) Structure—belly, tendon, attachment.
   (c) Hygiene—exercise, sprain and treatment.
3. Nerves (body control).
   (a) Need of co-ordination of body movements.
   (b) Apparatus: Sense or receptive organs; brain or co-ordinating organ; muscles or moving organs.
   Connection by way of nerve fibres.
   (c) Hygiene: Habit formation—shock and paralysis—sleep and quiet—eye strain. First aid.

X. *Public and Individual Sanitation* (Bacteria).

1. Bacteria—one celled plants.
2. Beneficial bacteria.
3. Harmful bacteria.
4. Conditions of growth.
5. Rate of growth.
6. Dispersal in
   (a) Air and dust. Tuberculosis.
   (b) Liquids: Milk, water, ice. Tuberculosis, typhoid.
   (c) Solid foods. Ptomaine poisons.
   (d) Animals including man: Bubonic plague, etc.
7. Methods of destruction.
8. Immunity—meaning of—natural and induced; vaccines and antitoxins.
9. Municipal sanitation.
   (a) Department of health—free examination of sputum, blood, urea, tubercular patients; free antitoxins, clinics, hospitals; quarantine; inspection of meat, milk, vegetables.
   (b) Department of street cleaning. Function; coöperation.
   (c) Department of sewers. Function; coöperation.
   (d) Department of water supply. Inspection and guarding of water supply. Coöperation.

Y. *Need of Reproduction* (Biology of Sex).

1. Review of reproduction in bacteria, higher plants and animals.
2. Purpose of reproduction in living things. Man no exception.
3. Essential conditions of reproduction. Comparison of plant, insect, fish and bird. Union of two cells to form a third from which the new individual is to grow.
4. Development.
   (a) Immature.
   (b) Mature.
   (c) Old.

   Significance of each stage.
5. Hygiene.
   (a) Evil effects of abuse of body parts in connection with over exercise, eating and drinking, eye strain, over study. Abuse of reproductive organs no exception. Effect upon all other organs of body. Effect upon offspring.
   (b) Infection: Public lavatories, public drinking cups, towels, combs, etc. Transmission to relatives. Transmission to offspring.
   (c) Applications of eugenics. Contrast of Edwards and Juke family. Recent laws.
   (d) Chivalry versus morbid curiosity.

Z. *Summary.*

1. Inter-relation between animal, vegetable and mineral kingdoms.
2. Great biologists—Darwin, Pasteur, etc.
3. Evolution—general principle. Man, nature's greatest creation.

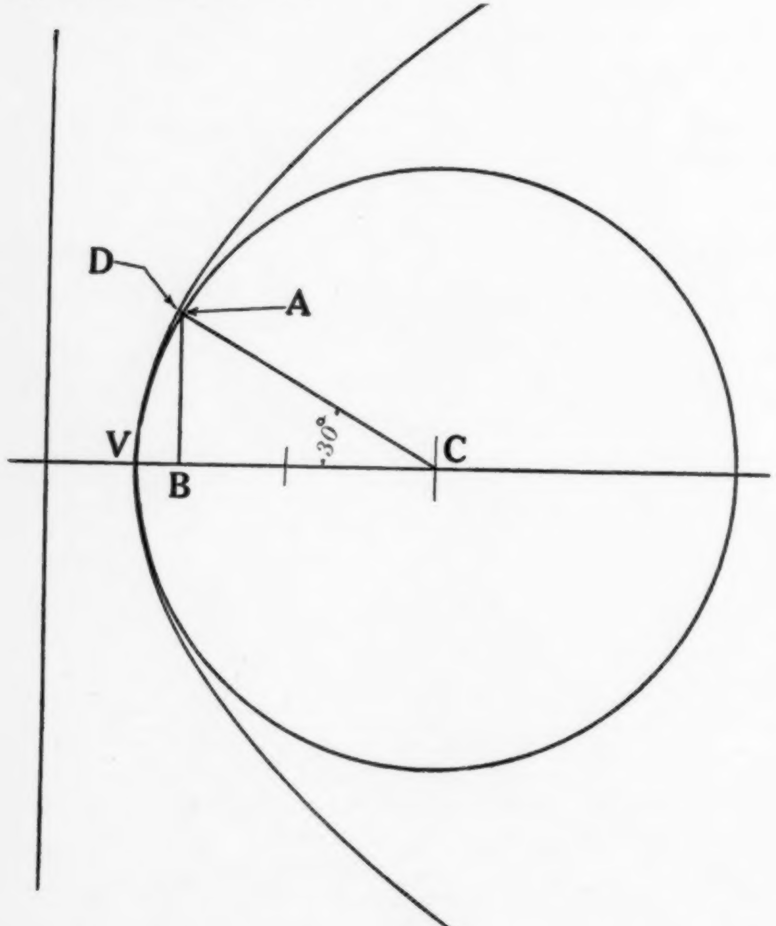
TELEPHONE GIRLS' EYES.

There are in the United States about 125,000 telephone girls, whose average term of service is three years or less. The working hours are about eight per diem; the average number of calls is about 140 per hour, running, "at the peak," to 225 or more. The operator sits facing a switchboard which is covered with numbers, each number having a small signal light that flashes on and off as the call is completed. When the person calling raises his receiver, a light flashes on the switchboard at "central," and this light continues to burn until the operator "plugs" the number and receives the call. She then plugs the number called for and this light burns until the called person raises his receiver from the hook. When the receivers are finally replaced on their hooks, both lights flash and burn until the operator removes the connecting plugs. To complete one call means four flashes of light. As the average number of calls is 140 per hour, with 225 or more during the rush hours, the operator's eyes are exposed to from 500 to 1,000 flashes of light every hour, resulting in fatigue to the eyes, to say nothing of the mental and physical strain under which the operator constantly works. The Bell system, in 1911, spent $720,953 for rest-rooms and lunch-rooms for the operators, and it has secured sufficient air space and good illumination, yet, although only young and healthy girls are selected, the average length of service does not exceed three years. The symptoms of eye-strain which the girls develop are headache, dullness, indigestion, exhaustion, nerve strain, insomnia, colds, and so forth. The two or three short years of telephone work possible to the girls, as well as nine-tenths of all their suffering, is probably due to the constant near-range eyework, without proper protection for the eyes.

GRAPHICAL REPRESENTATION OF THE ERROR IN THE MIRROR FORMULA.

By James S. Stevens,
University of Maine.

In developing the formula $1/P+1/P' = 1/F$ it is necessary to make use of a certain approximation when applied to circular apertures. For parabolic apertures this approximation does not appear. The following method expresses the magnitude of the approximation graphically.



Let the equation for the parabola be represented by $y^2 = 4px$. Assume the radius of the circle to be $2p$ and the origin at the center. Then the equation of the circle is $x^2+y^2 = 4p^2$. For

simplicity let $p = 1$ in each curve. The angle ACB is taken to be 30°. What is the error in the formula for the aperture? Here AB = 1, and BC = 1.73. Therefore VB = 0.27. Taking this value for X in the parabola we have

$$y^2 = 4 \times 0.27 = 1.08 \quad y \doteq 1.04.$$

This is B D in the figure. We thus see that for an aperture of 30° the ratio of the lengths, 1.00 and 1.04, gives a measure of the error made by using a circular aperture. For 45° the ratio comes out 1.41 : 1.53: and for 90° it is 2 : 2.83.

It is to light waves falling at those large apertures that caustics are due. For smaller apertures the error is much less. Thus for 5° the ratio is 0.174 : 0.178.

For 1° BA $\pm$ 0.0349 : BD = 0.0352.

Those ratios are for paths of light which start from B and pass in a vertical direction, striking first the circle and then the parabola. For sources at other points on the axis the ratios would change slightly for different apertures.

When a student begins the study of applied mathematics it is very difficult for him to get accustomed to making approximations. It seems as though the accuracy of pure mathematics is being sacrificed. Such a figure as this will tend to show that it is perfectly safe to use approximate formulae within proper limits.

CHECK ON THE DEVELOPMENT OF MENTAL DEGENERACY.

There are about fifty thousand persons of unsound mind in Hungary at the present day. Dr. Décsi has drawn attention to the fact that more than one-third of this insanity is caused by drink and venereal diseases. He suggests the following rules for checking the development of mental degeneration at the present day: 1. Prevention of those who have been insane once from marrying. It may be stated as a certainty that many women who have had one attack of lunacy would have remained free from a second attack had they not married. 2. Immediate legislation for compulsory confinement of habitual drunkards, who are the greatest propagators of lunatics and degenerates, and who should therefore be legally restrained from inflicting their own vice on other human beings. 3. Prohibition of marriage by habitual drunkards. 4. Care in the administration of alcohol to women, as this very often makes the offspring a drunkard or a lunatic. 5. General reformation of the marriage system with certain health requirements. 6. Prohibition of marriage when hereditary insanity exists on both sides. 7. Prohibition of marriage by paralytics, epileptics, consumptives and those affected with cancer. 8. Restriction of the liquor trade. 9. The establishment of intermediate houses, so to speak, where those suffering from acute, but curable, insanity could be placed instead of being incarcerated in lunatic asylums.

A SAFETY GENERATOR FOR GASES.

By Theodore Cohen,
Commercial High School, Brooklyn.

Although the time-honored "thistle-tube apparatus" for generating gases has the advantage of being quickly constructed, still there are many disadvantages which frequently make its use inadequate and inconvenient.

First, the total lack of control of the pressure of the gas. Should the reaction proceed with too great violence, the gas, unable to escape rapidly enough through the delivery-tube, especially when under water, frequently forces out the cork, spattering the acid contents. If, however, under these conditions, the cork should resist the excess pressure of the gas, then the acid is forced over into the delivery-tube and ultimately into the collecting apparatus.

Secondly, the lack of control of the supply of the gas. Once the reaction has begun the gas continues to come off until the materials have been exhausted, even after its use has been discontinued. In other words, there is lack of economy. New materials are required if the apparatus has not been in use for some time. There is no mechanism whereby the reaction could be stopped when the gas is not in use.

Thirdly, in cases where heating is necessary to start the reac-

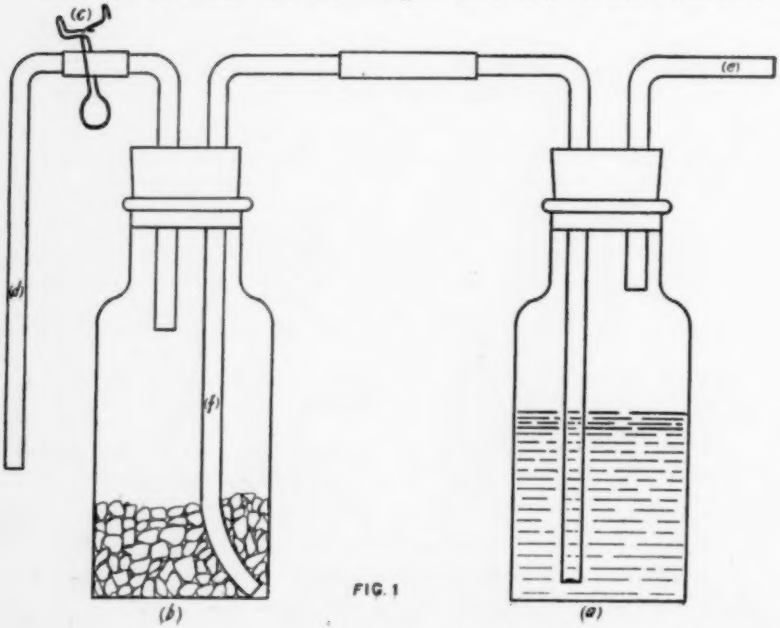


FIG. 1

tion, and the delivery-tube is under water, the liquid would "suck back" into the generator, should one forget to remove the delivery-tube at the same time the flame is removed and as a result, the heated glass frequently cracks.

These are only a few of the serious and most obvious disadvantages in the use of this apparatus which requires constant attention, if all possible accidents are to be avoided.

The writer has therefore designed an apparatus, which, although it requires at the outset a little more care and time to construct, can be used again and again, does away with the above disadvantages and has several unique advantages of its own.

Figure 1 shows the apparatus set up ready for use. Bottle (a) contains the acid, (b) the substance, (c) is a pinch-cock of the Mohr or Hoffmann type depending altogether whether the gas is to be shut off at once or whether its supply is to be regulated, (d) the delivery-tube, and (e) the tube through which pressure is applied. Tube (f) is bent so as to reach to the corner of the bottle. The gas is generated by opening the pinch-cock, blowing into tube (e), which forces the acid over into the bottle (b) and starts the reaction. The reaction can be stopped by closing the pinch-cock, when the pressure of the gas will force the acid back into bottle (a). It is only necessary to open the pinch-cock again and blow into (e) to repeat the process.

An inspection of the diagram will reveal the following facts. The check on excess pressure is always in operation when the reaction becomes too violent. The supply of the acid is automatically regulated by the pressure of the gas in bottle (b). Should it be necessary to add new materials, the bottles can be readily removed and connected again. At times, when the supply of the gas is stopped in the generating bottle, gas will still continue to come off from bottle (a) due to small particles of the substance having found their way over into the acid. This gas can also be collected by simply removing the delivery-tube and attaching it at (e).

Sometimes the pressure of the gas in (b) is less than that of the liquid at the exit of the delivery-tube when immersed. This would drive the acid back into (a). Closing the rubber tube connecting the two bottles by means of a Hoffmann pinch-cock would remedy this difficulty and insure a steady supply of gas on account of increased pressure.

In many laboratories where qualitative analysis is given, no general house supply for hydrogen sulphide is available. In those

cases, this apparatus can be used by the student to great advantage. Each worker is assured of his supply of gas at any moment, and does away with the inconvenience of having the students crowd around a single Kip generator.

Again, the whole apparatus lends itself very readily to being cleaned and used for different acids and materials.

It is not necessary to confine oneself to bottles only. Flasks or large test-tubes can be substituted and in cases where heating is required to start the reaction, the liquid can be heated in one flask and while hot, forced into the generating flask.

This apparatus is a modification of the Kip generator and works on a similar principle.

A serious objection may be raised in that contact of tube (e) and the mouth is necessary. This can be readily overcome by using a piece of rubber tubing which can be detached when not in use, thus preventing possible contact with the acid should any of it happen to get into tube (e), or a rubber bulb attachment can be substituted, and should be detached when the reaction has begun.

This apparatus can be readily used to generate such gases as hydrogen, hydrogen sulphide, carbon dioxide, etc. In fact, all those gases that can be prepared with a Kip generator.

ACETYLENE GENERATOR.

By Theodore Cohen,
Commercial High School, Brooklyn.

A slight modification of this apparatus gives an acetylene gas generator which can be used for demonstration purposes. The apparatus shown in Figure 1 can be turned into such a generator by substituting a three-hole stopper in bottle (b) and adding the thistle-tube attachment as shown in Figure 2.

Water is placed in the thistle-tube, some calcium carbide in bottle (b) and bottle (a) is filled two-thirds with water, or sulphuric acid, if the gas is to be washed. The delivery-tube is removed and an acetylene burner is substituted as shown (d). When the reaction has been started by admitting water into bottle (b) from the thistle-tube, the acetylene gas which is generated, $CaC_2+2H_2O = Ca(OH)_2+C_2H_2$, takes the course of least resistance and goes through the burner.

This form of apparatus has the following advantages: The pressure of the gas is automatically controlled, since an excess

pressure will force the gas through bottle (a). At one operation (when the reaction is made more violent) the issuing gas can be burnt at the burner and at the end of tube (e), showing the smoky flame and the intense brilliant white flame of acetylene gas. And finally, by simply closing the pinch-cock of the burner and attaching a delivery-tube to (e), the gas can be collected and its properties noted. All this takes place without disconnecting any part of the apparatus, thus avoiding the possible access of air. In the ordinary thistle-tube arrangement this is altogether impossible, since disconnecting the apparatus may cause an explosion due to the access of air.

A piece of wire gauze attached to the orifices in the bottles of the tubes (e) and (c) will further insure against any possible explosion.

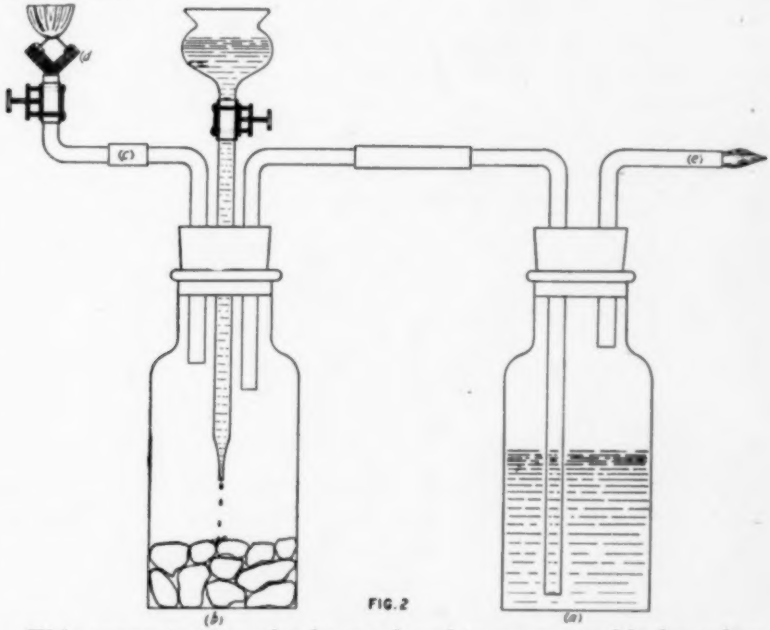


FIG. 2

This apparatus can also be employed to generate chlorine when concentrated hydrochloric acid and potassium permanganate are used. The acid is placed in the thistle-tube, the permanganate in bottle (b), and a delivery-tube and pinch-cock added instead, at (c). Bottle (a) contains water and when the gas is not being collected, both pinch-cocks are closed and the gas that continues to come off can then be utilized for saturating the water in bottle (a), for future use. Bottle (a) also shows the rate at which

the gas is being generated. The safety check is all the time in operation.

This apparatus can be used for any gas that depends for its formation on the same principle as that of chlorine.

For example, oxone when placed in bottle (b) and water in the thistle-tube will give a steady supply of oxygen gas.

THE VALUE OF THE SKUNK TO AGRICULTURE.

The skunk which is represented throughout the country by a number of varieties, genera and species, is an animal of great economic importance. Its food consists very largely of insects, mainly of those species which are very destructive to garden and forage crops. Field observations and laboratory examination demonstrate that they destroy immense numbers of white grubs, grasshoppers, crickets, cut-worms, hornets, wasps, and other noxious forms. The alarming increase of the white grub in some localities is largely due to the extermination of this valuable animal.

It is a matter of common observation where white grubs are particularly abundant in corn fields to note little round holes burrowed in the ground about hills of corn. These are made by skunks in their search during the night for these grubs. During the recent outbreak of grasshoppers in Kansas it has been determined that in many cases a large proportion of the food of skunks consisted of these grasshoppers.

Some of the most destructive insects in agriculture are such as do their work below ground and out of reach of any method that the farmer can apply and it is against many of these that the skunk is an inveterate enemy. Notwithstanding all of this, there is probably not an animal that is as ruthlessly slaughtered as is this one, whereas it is equally entitled to protection with, if not more so than, some of our birds which enjoy this privilege.

In some regions, especially in the southwest, the bite of the skunk is supposed to produce hydrophobia. This fear is unfounded since it is proved that the bite of a healthy skunk is no more serious than similar wounds caused by other agencies.

In connection with the work of the range caterpillar investigations in northeastern New Mexico, it has been found that skunks destroy a great many of the pupae (chrysalis) of this caterpillar and in fact, during September and October when this food is easily available, they prefer it to all others. About the middle of September it was discovered that many webs were empty, the pupae having been neatly extracted from the web and either carried off or eaten. In many areas containing hundreds of acres from twenty-five to seventy-five per cent of the pupae had been carried off, while in a few isolated places as high as ninety-five per cent of the *Hemileuca* (Mexican range caterpillar) pupae were gone. Following these observations, piles of skunk excrement were found which consisted in some cases almost entirely of pupae shells. Subsequent counts made show the excrement found to have from sixty to ninety-five per cent of its contents consisting of these crushed shells. On the Crow Creek Ranch there was not an area observed but what had some of the *Hemileuca* pupae destroyed by these animals. It is thus seen that the common skunk is at the present time one of the most important factors looking toward the control of *Hemileuca* outbreaks and should be protected by the ranchers in the infested district.—*U. S. Department of Agriculture.*

EXPERIMENTS IN CHEMISTRY.

The Minneapolis chemistry teachers have prepared a manual of experiments which is the result of five years of careful study. Some of the experiments are unique in that they have not before appeared in a published manual. Several are printed below to show the general character of the work. We believe far too little attention is given to specific directions and careful wording of text in the average manual. The Minneapolis teachers have made consistent efforts to avoid this fault and have succeeded very well. The specific attention to the study of properties is a notable feature of the manual. Among other points are elimination of danger in handling sodium, saving of time by measuring reagents by spoonfuls, methods which give positive results, and the definite working out of conclusions. The mânual is just off the press. Sample pages, index and explanatory preface will be sent to teachers interested, or the book itself for 35 cents. H. R. SMITH, *Chairman.*

HYDROGEN.

A. Preparation.

1. Have ready a test tube one-third full of distilled water. Set it in a rack. With a pair of forceps, drop a small piece of freshly cut sodium into the tube. Test the hydrogen gas given off by bringing a blazing splinter to the mouth of the tube. State the result. From which substance does the hydrogen come?

Add a second piece of sodium. How does the metal act? What evidence of heat do you notice? Look through the water for material streaming down in it. Rub a little of this liquid between the fingers. What does it feel like? Test it with a strip of red litmus paper. State the result. These two properties are characteristic of a class of compounds called bases. In this case the base is sodium hydroxide. Write the equation.

2. Place a test tube in a rack. Pour into it a little hydrochloric acid. Drop into the acid a two-inch strip of magnesium and quickly test for hydrogen with a flame. Result? From which substance does the hydrogen come in this case?

3. *Laboratory Method of Preparing Hydrogen.*

Caution: Keep flames away. N. B. Wetting rubber stoppers and tubing allows glass to slip into them better; when you use a thistle tube screw the end to the bottom of the generator.

Set up the apparatus as shown in the model. Have six bottles ready for collecting hydrogen "over water." Put a small handful of granulated zinc into the generator and insert the stopper. Sketch and label the apparatus. Add enough dilute sulphuric acid through the thistle tube to cover the zinc. Result? Collect the gas, setting aside the first bottle, which contains a mixture of hydrogen and air, for use in part *B* 2. Keep the bottles of hydrogen inverted until you are ready to use them. After the action in the generator has ceased put a drop of the liquid upon a glass plate and let it stand until crystals of zinc sulphate form. Describe them. Write the equation. Wash with water any zinc left in the generator and return it to the instructor.

4. What two general methods of *preparing* hydrogen are illustrated in the preceding paragraphs?

B. Properties of Hydrogen.

Read each paragraph through carefully before performing the experiment.

1. Lift up a bottle of the gas, while inverted light the hydrogen, and set the bottle upright on the table. The hydrogen should not explode but burn

quietly for some time. Look closely for the almost invisible flame. If you do not get these results, try again with another bottle.

2. Repeat, using the bottle containing the mixture of hydrogen and air saved from *A* 3. Compare the burning of the mixture with the burning of pure hydrogen.

3. Hold another bottle of hydrogen mouth upward, for one full minute. Insert a blazing splinter. Result? Repeat, with an open bottle of hydrogen, mouth down. Result? Explain the difference.

4. Insert a burning candle into an inverted bottle of hydrogen. State two results. Withdraw it slowly. Result? Repeat two or three times. Explain.

5. State (a) five physical properties and (b) three chemical properties of hydrogen determined by this experiment.

THE OXIDES OF NITROGEN.

I. Nitrous Oxide, N_2O.

Put into a test tube one spoonful of ammonium nitrate and arrange the apparatus for collecting the gas over water. Sketch the apparatus. Heat gently until the ammonium nitrate is all melted and then heat strongly enough to produce a steady flow of gas *keeping the flame under the end of the test tube.* Collect two bottles of the gas, and quickly remove the delivery tube from the water. Write the equation for the preparation of nitrous oxide. Note the odor of the gas.

State four physical properties of nitrous oxide which are shown in this experiment. Test with a *glowing* splinter. Result? This is due to the fact that the heat of the glowing splinter decomposes the nitrous oxide into nitrogen and oxygen and the oxygen supports the combustion. What two chemical properties are shown? Name the residue in the generator.

II. Nitric Oxide, NO.

A. Preparation and Physical Properties.

Set up the apparatus as for preparing hydrogen. Put into the generator one spoonful of pieces of copper, add water to the depth of half an inch, and pour through the thistle tube an equal volume of concentrated nitric acid. Collect four bottles of the gas over water, rejecting the first. Leave the bottles of gas in the water until needed. Write the equation. Sketch the apparatus. State three physical properties of the product collected.

B. Chemical Properties.

1. (a) Raise a bottle of the gas out of the water without covering it. Result? Replace the bottle in the water. State two results. What causes the nitric oxide to change to the brown gas, nitrogen peroxide, NO_2? Write the equation. What became of the nitrogen peroxide after the bottle was replaced in the water? Prove that there is some nitric oxide left in the bottle, stating your method and the result. What color was the gas in the generator? Why? What must have become of the colored gas before it could reach the bottle in the sink?

(b) Set up an apparatus and generate oxygen *very slowly*. Bubble it into a bottle of nitric oxide inverted in water, and notice that although you are continually adding more gas, the volume of the gas in the bott.e is decreasing. Explain.

2. Lower a blazing splinter to the bottom of another bottle of nitric oxide. Result? Allow the cover to remain off until the bottle is full of nitrogen peroxide and test it also with a blazing splinter. Result?

3. State three chemical properties of nitric oxide.

Thoroughly wash the copper in the generator with water and return it to a receptacle provided for that purpose.

III. Nitrogen Peroxide, NO_2.

1. State a method by which you have already prepared nitrogen peroxide and name four physical and two chemical properties of it shown in *B* 2.

2. Set up the apparatus as for nitrous oxide but arranged to collect the gas by downward displacement. Heat in the generator one-fourth of a spoonful of lead nitrate and collect one bottle of gas. What color is the gas that you see? Test the gas in the bottle with a *glowing* splinter. Result? The yellow solid in the generator is the lead oxide, PbO. Write the equation. What two gases were collected in the bottle? Which one causes the action on the splinter? Collect a test tube of gas over water. What is its color? Name the gas and prove your answer by experiment.

What one additional property of nitrogen peroxide was shown in 2?

IV. Summary.

Arrange four parallel columns. In the first write the following topics: (1) *Formula,* (2) *Preparation,* (3) *Equation,* (4) *Method of Collecting,* (5) *State,* (6) *Color,* (7) *Odor,* (8) *Soluble or not,* (9) *Calculate the Molecular Weight,* (10) *Calculate the Specific Gravity,* (11) *Calculate the Weight of one Liter,* (12) *Supporter of Combustion or not.* Head the last three columns, *Nitrous Oxide, Nitric Oxide,* and *Nitrogen Peroxide,* respectively, and tabulate your results.

TO STUDY THE OXIDIZING ACTION OF SODIUM AND POTASSIUM NITRATES.

A. Sodium Nitrate.

Into an evaporating dish put 10 grams of sodium nitrate and 20 grams of lead, and heat without a gauze, stirring constantly with a small *dry* test tube. Continue heating until the whole mixture becomes a thick orange paste and the lead is entirely gone. The orange powder is lead oxide, PbO. Scrape the hot mass into an iron mortar and pulverize. Put the material back into the evaporating dish, cover well with water, and bring to a boil; then filter the hot liquid. Finish the equation: $NaNO_3 + Pb = PbO +$.

Name the second product. It will be found in the filtrate. Why? Add to the filtrate several drops of concentrated sulphuric acid. Result? This behavior is characteristic of a nitrite. What are substances called that act as the lead did in this experiment? As the sodium nitrate did?

B. Potassium Nitrate.

1. Into an old *dry* test tube held in a clamp put about ⅛ of a spoonful of potassium nitrate and heat until it boils; drop in a very small piece of charcoal. If nothing happens, heat more. Describe what takes place. When the charcoal is gone, heat again as before and drop in a small piece of roll sulphur. Describe and account for these two results.

2. Dissolve a little potassium nitrate in a small amount of warm water in an evaporating dish. Write your initial on a piece of filter paper, using the solution and a paper point, and hang up to dry (paper point made by wrapping paper around the finger).

Paper soaked in potassium nitrate solution and dried is called *"Touch Paper."* Light the paper where there is some potassium nitrate, by touching it with a hot wire or glowing splinter. Describe the result and explain.

3. *Gunpowder.* On a sheet of paper put 3 grams of powdered potassium nitrate, and ½ gram each of flowers of sulphur and powdered charcoal, and mix thoroughly with the side of a test tube. Burn it on a piece of asbestos or brick. Describe the combustion, the color of the flame and residue if there is any. Put a little of the residue into a test tube and add

a little concentrated hydrochloric acid. What odor do you notice? This is proof that one component of the residue is a sulphide.

The kind of burning illustrated in this experiment is called deflagration. In what respect does it differ from ordinary burning? What is the source of the oxygen?

TO STUDY PHOSPHORUS.

Caution: Yellow phosphorus and its solution ignite very easily and may cause painful burns. Be careful not to get any on the hands or clothes.

1. Describe red and yellow phosphorus.

2. Test the solubility of a bit of red phosphorus in water and in carbon disulphide. Judging from the way in which yellow phosphorus is kept, is it soluble in water?

3. Rub an ordinary match head with a wet finger. Describe the odor. What evidence of chemical action is seen? Write the equation for the action of the air on the phosphorus, assuming the valence of phosphorus to be five.

4. Dissolve a small bit of yellow phosphorus by letting it stand in a test tube with enough carbon disulphide to cover it well. Lay a piece of filter paper on a ring of a ring-stand and pour all of the solution of phosphorus upon it, spreading it around as much as possible. Watch it closely. What becomes of the carbon disulphide? Look for signs of chemical action and describe all that takes place.

The finely divided phosphorus on and in the paper oxidizes as soon as the carbon disulphide has evaporated and the heat generated accumulates in the porous paper and finally raises the phosphorus to its kindling temperature, which is 35 degrees C. or 95 degrees F. Why was it necessary to get the phosphorus into solution?

5. Supply yourself with a piece of glass tubing about 5 inches long and put a bit of red phosphorus into one end, shoving it to the middle of the tube with a match stick. Then mount it securely in a clamp as shown in the model. Keep away from the ends of the tube from now on except as directed. Heat the spot directly under the red phosphorus gently for some minutes. Does the red phosphorus melt? After a time a deposit will be seen within the tube and at some distance from the red phosphorus. What is its state and color? What is the newly formed deposit? Tell your answer to the instructor. If correct, prove your answer by blowing through a blow pipe into the tube. Burn all of the phosphorus. Why did it not burn before? What color is the deposit after the fire is out? When the yellow phosphorus burns, the heat of combustion changes some of the yellow phosphorus to red. Prove that it is red phosphorus by heating it, and blowing through the tube as described above. State a method of showing that the rubbing surface of a safety match box contains red phosphorus. Have it approved by the instructor and then do it. Burn all yellow phosphorus and throw the tubes into the waste jars.

6. Put a piece of yellow phosphorus half as big as the head of a pin upon several thicknesses of paper and see if you can ignite it by rubbing it with the flat end of a match stick or splinter. Result? What use of phosphorus depends on the property shown? Did the stick take fire? Why is sulphur or paraffin necessary in a match head between the phosphorus and the wood? Try to ignite a bit of red phosphorus by rubbing as described above. Result? Try to ignite a bit of red phosphorus by holding it in a flame on a pair of forceps. Result?

7. Summarize the properties of red and yellow phosphorus in a table of three columns, in the first of which are the headings: Color, Odor,

Solubility, Kindling temperature, Effect of heat without air, Action when cold in air, Action when hot in air.

To Make a Safety Match.

A. The Rubbing Surface.

Mix in an evaporating dish, 4 drops of thin glue, one-fourth as much red phosphorus, and as much finely powdered quartz as phosphorus. With the finger spread the mixture thinly on a piece of pasteboard. This will cover about three square inches. Allow to dry several hours or a day.

B. The Match.

Whittle some sticks into the shape desired. Soak the ends in hot paraffin for a second or two. Prepare a mixture of 3 drops of *thin* glue, one-third as much powdered antimony sulphide, Sb_2S_3, and twice as much powdered potassium chlorate as glue. Dip the prepared sticks into this mixture, and dry several hours. This will make 8 or 10 tips. When dry, see if you can light one.

Silvered Mirrors.

Prepare a tray as follows: Fold up one-half inch of the sides of a piece of paper about 4 by 5 inches in size and fasten the corners by means of pins or clips. Pour into the tray hot melted paraffin and thoroughly wet the inside of the tray. Return the excess of paraffin.

Balance the scales and weigh out one-fourth gram (250 mg.) of silver nitrate. Weigh out one gram of Rochelle salt (sodium potassium tartrate).

Clean a large graduate, a small graduate, a funnel, a plate of glass, and four small flasks or beakers. Make a chromic acid cleaning mixture by covering a few potassium bichromate crystals with concentrated sulphuric acid and heating in a beaker. *(This mixture is very corrosive, use extreme care in handling it.)* Rinse each article with the hot mixture, then with several changes of water, then with distilled water. Do not try to dry the apparatus. Label the flasks A, B, C, and D. Into A put the silver nitrate and 25 cc, of distilled water. Into B put the Rochelle salt and 50 cc. of distilled water. Into C put 2½ cc. of solution B and 25 cc. of distilled water. Boil solution B very slowly for ten minutes. Then add to it 2½ cc. of solution A. Boil this for one minute. Filter into D. To the remainder of solution A add a drop of ammonium hydroxide and shake the mixture. Continue adding ammonium hydroxide drop by drop, shaking well after each drop, until the brown precipitate begins to dissolve. Mix solutions A and D and pour one-half of the mixture upon the prepared glass, set in the paraffined tray. Let the solutions in the tray and in the flask act for at least ten minutes. Remove the glass plate and rinse with water. Remove any silver that may be upon the face (under side) of the mirror with a little dilute nitric acid on a swab of cloth, rinse again, and allow it to dry. (Dark spots and irregular deposits are due to imperfect cleaning.) The silver deposit may be protected by covering it with melted paraffin.

The ammonium hydroxide precipitates silver oxide and this is reduced by the organic material, Rochelle salt (R), to metallic silver. Write the two equations.

Jessie Caplin, *West High.*
Louis G. Cook, *East High.*
Perley Davis, *North High.*
B. T. Emerson, *Central High.*
Kate MacDermiel, *South High.*
Minneapolis, Minn.

SCIENCE QUESTIONS.

BY FRANKLIN T. JONES,
University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE AND MATHEMATICS *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

141. *Proposed by G. V. Sosnow, Newark, N. J.*

How much steam at 100° C. must be mixed with 1272 gm. of ice at 0° C., so that after the changes of state the result may be water at 0° C.?

142. *Proposed by Harvey Roeser, Stillwater, Okla.*

A person standing directly in front of the vertical middle line of a square post throws a slip noose over it and draws the line taut. It is a fact that the rope can not be drawn up to fit the post snugly. What will be the angle between the rope and the post?

143. *Proposed by R. C. Colwell, Beaver Falls, Pa.*

A body is projected upwards with any velocity and t, t_1 denotes the times in which it is respectively above and below the middle point of its path. Find the value of t/t_1. (Williamson, Particle Dynamics, p. 37.)

144. *From Morgan & Lyman's Chemistry, p. 332, No. 3. (Macmillan.)*

The average family uses 20 tons of water in a year, one-tenth of which is used with soap. If the water is hard and contains .01 per cent of calcium sulphate, what is the approximate value of soap wasted each year, supposing soap to be $NaC_{18}H_{33}O_2$? (A 5-cent cake of soap weighs about 10 ounces and often contains 40 per cent of water.)

145. *Proposed by the Editor.*

The average hardness of the water of Cleveland is 13.6 parts per million of which about half may be remedied by water softening on the large scale proposed by the new filtration system. Assume the average water consumption at 100 gallons per day per person and the number of people served by the Greater Cleveland Water Works system at 750,000, also that one-one-hundredth only is used with soap. Using the same data for soap as in problem 144, what will be the annual saving in soap alone?

Answer serially numbered questions in the following list:

UNIVERSITY OF THE STATE OF NEW YORK—CHEMISTRY.

Answer 10 questions, selecting at least one from each of the groups I, II, III and V, and at least one from either group IV or group VI.

GROUP I.

Answer at least one question from this group.

1. What chemical reaction could one use to distinguish between (*a*) oxygen and hydrogen, (*b*) a solution of a chloride and a solution of a nitrate, (*c*) a ferrous salt and a ferric salt, (*d*) carbon dioxide and nitrogen, (*e*) silver and platinum? [10]

2. Mention an important commercial source of ammonia [2]. Ammonia was passed into water and this solution was neutralized by introducing nitric acid; what reaction took place when (*a*) the ammonia was passed

[2], (*b*) the nitric acid was introduced [2]? How could one obtain from the solute in the neutralized solution (*a*) ammonia [2], (*b*) nitric acid [2]?

3. For the preparation of chlorine by a laboratory method (*a*) make a diagram of the apparatus used [2], (*b*) give the names of the chemicals employed [2], (*c*) write the equation representing the reaction [2]. What reaction takes place when a water solution of chlorine is exposed to the sunlight [2]? State an important commercial use of chlorine [2].

Group II.

Answer at least one question from this group.

4. Define acid, base, salt, ion, destructive distillation. [10]

5. What is meant by the periodic law [4]? Name *three* elements in each of *two* series illustrating this method of classication [6].

6. State the law of (*a*) definite proportions [3], (*b*) multiple proportions [3].

146. Carbon dioxide contains 27.27 per cent of carbon and 72.73 per cent of oxygen, and carbon monoxide contains 42.86 per cent of carbon and 57.14 per cent of oxygen; show how the composition of these compounds illustrates the law of multiple proportions [4].

Group III.

Answer at least one question from this group.

7. Write a chemical equation to represent *each* of the following: [10] (*a*) the reaction between zinc and dilute sulphuric acid, (*b*) the reaction between copper and diluted nitric acid, (*c*) the reaction between zinc and a solution of lead nitrate, (*d*) the reaction between acetic acid and alcohol in the presence of concentrated sulphuric acid, (*e*) the chemical change that takes place when magnesium carbonate is heated.

8. How many liters of sulphur dioxide could be obtained by adding sufficient hydrochloric acid to 63 grams of sodium sulphite? [10] [Atomic weights: $Na = 23$, $S = 32$, $O = 16$.]

9. How many liters of oxygen would be required for the complete combustion of 20 liters of marsh gas (methane)? [10]

Group IV.

Answer at least one question from either this group or group VI.

10. Describe a commercial process for the manufacture of sodium carbonate from salt [6]. Represent by chemical equations the important reactions that take place [4].

11. Compare, with respect to composition, elasticity and malleability, cast iron with (*a*) wrought iron [3], (*b*) steel [3]. Which material mentioned is suitable for (*a*) electromagnets [2], (*b*) ball bearings [2]?

Group V.

Answer at least one question from this group.

12. What is the meaning of the word fermentation as used in chemistry [2]? Describe, making use of a chemical equation, a process by which carbon dioxide and alcohol are obtained [4]. Mention *two* important changes that take place during the conversion of sweet cider into vinegar [4].

13. The production of crops is likely to cause a soil to become deficient in what three elements [3]? In the case of each element named mention one of its compounds used in commercial fertilizers [3]. Mention an industrial process for the fixation of atmospheric nitrogen [4].

GROUP VI.

Answer at least one question from either this group or group IV.

14. Give a chemical test by which one may determine whether a fabric is all wool or has some cotton in its texture. [10]

147. What is the chief chemical difference between a baked potato and a boiled potato [5]? Why does this difference exist [5]?

Solutions and Answers.

121. *Proposed by A. Bjorkland, Appleton, Wis.*

What will be the daily cost of pumping 500 gallons of drinking water by means of the following compressed air system? The air in the supply tank is kept at a very nearly constant pressure of 75 pounds per square inch. The pump is so arranged that the air acts directly on the pump piston with full pressure, and, for each gallon of water forced out, a gallon of compressed air enters and escapes from the pump. The temperature of the air entering the pump is 12° C. Before and after entering the compressor, 20° and 120° C.

Assuming the efficiencies of the pump, compressor and electric motor to be 80, 70 and 75 per cent respectively, what will be the daily cost at 8¢ per kilo-watt-hour?

(This is a "real" problem which came to the attention of the Physics department at the Appleton High School.)

Solution by the Proposer.

500 gallons of air at 12° C. and 89.7 pounds pressure (75+14.7) must be forced into the pump. This equals 66.84 cubic feet, and is equivalent to 419.3 cubic feet at 20° C. and 14.7 pounds pressure; and 92.17 cubic feet at 120° C. and 89.7 pounds pressure. The work done in compressing the 419.3 cubic feet to 92.17 may be computed from the formula $(P_2V_2—P_1V_1)/(n—1)$ where n has some value between 1 and 1.41 depending on the degree to which the compression is adiabatic. The value of n may be found by substituting in the formula $P_2/P_1 = (V_1/V_2)^n$ or $89.7/14.7 = (419.3/92.17)^n$, from which n equals 1.194. Substituting in the first formula, the compressional work equals $(89.7\times92.17—14.7\times419.3)(144)/(1.194—1)$ or 1,561,700 foot pounds. The work done in forcing out the 92.17 cubic feet of air equals $89.7\times144\times92.17$ or 1,190,500 foot pounds. The work done by the atmosphere in aiding the compressor equals $14.7\times144\times419.3$ or 887,600 foot pounds, leaving the work done by the compressor 1,864,600 foot pounds. This divided by the combined efficiency of the compressor and motor and reduced to kilowatt-hours becomes 1.34, costing at 8¢, 10.7¢.

Notes on solution of problem 121.

The formula for compressional work is derived by integrating the general formula for work, work $= \Sigma\, P\,dV$, with aid of the compressional curve equation, $P/P_2 = (V_2/V)^n$. Substituting $P_2(V_2/V)^n$ for P, we have,

$$\text{work} = \int_{V_2}^{V_1} P_2(V_2/V)^n dV, \quad \text{or work} = P_2V_2^n \int_{V_2}^{V_1} V^{-n}\, dV.$$

Integrating, work $= P_2V_2^n(V_1^{1-n}—V_2^{1-n})/(1—n) = P_2V_2—P_1V_1)/(n—1)$.

92.17 cubic feet must be forced out of the tank in order to cause 66.84 cubic feet to enter the pump on account of the fall in temperature. The efficiency of the pump is not considered since it merely affects the available pressure of the water and not the work done.

126. *Also solved by R. T. McGregor, Coleville, Cal., and Henry Roeser, Agricultural and Mechanical College, Stillwater, Okla.*

129. *From Millikan & Gale's Physics (Revised) page 196. (Ginn & Co.)*

It requires a force of 300 kilos to drive a given boat at a speed of 15 knots (25 km.). How much coal will be required to run this boat at this speed across a lake 300 km. wide, the efficiency of the engines being 7 per cent and the coal being of a grade to furnish 6000 calories per gram?

Solution by Henry Roeser, Stillwater, Okla.

300 kg. = 300,000 gr.

300 km. = 30,000,000 cm.

Total work to take boat across = $980 \times 9 \times 10^{12}$ ergs.

Mechanical equivalent of 1 cal. = 42×10^{6}.

Work done by 1 gr. of coal = $.07 \times 6000 \times 42 \times 10^{6}$.

$$\text{Coal required} = \frac{980 \times 9 \times 10^{12}}{.07 \times 6000 \times 42 \times 10^{6}} = 500 \text{ kg.}$$

Also solved by G. Y. Sosnow, Newark, N. J.

130. *Proposed by C. A. Perrigo, Dodge, Neb.*

Since 100 degrees C. equals 212 degrees F., why does not —100 degrees C. equal —212 degrees F.?

Solution by Dwight W. Lott, Van Wert, Ohio.

Although I do not believe in a quibble over words, I think the question should be worded somewhat differently, as follows: Since a temperature of 100 degrees C. is equivalent to a temperature of 212 degrees F., why is not a temperature of —100 degrees C. equivalent to a temperature of —212 degrees F.? You will see that I do not say that 100° C. equals 212° F., because we prove in the solution that 100° C. equals 180° F. if we use the term "equals" in its true sense.

The figures given apply to H_2O at a pressure of 76 cm. of Hg.

	C.	F.
Boiling Point	100°	212°
Freezing Point	0°	32°
Difference	100°	180°

100° and 180° both represent the same difference in temperature, namely, the difference between the boiling point and freezing point of H_2O.

Therefore 100° C. = 180° F.

Now, —100° C. means (1) 100° below zero C.
(2) 100° below freezing point.

The same difference in temperature means on the F. scale a temperature of 180° below the freezing point, *but not 180° below 0°F.* 180° below freezing point, 32° F., is —148° F. Therefore a temperature of —100° C. is not equivalent to a temperature of —212° F., but is equivalent to a temperature of —148° F.

Also solved by Kearn B. Brown, Grangeville, Idaho.

MEETING OF NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

GENERAL SESSION.

Central High School, Syracuse, N. Y.

The following resolutions were presented by Mr. L. E. Jenks of the Ogdensburg High School:

I. Resolved, That article VII of the Constitution be amended to read as follows:

ARTICLE VII.

SCHOOL SCIENCE AND MATHEMATICS shall be the official publication of the New York State Science Teachers' Association.

The active membership of this Association shall be divided into two classes. Class A shall include, except as hereafter provided in class B, all the active members of this Association in good standing.

They shall receive SCHOOL SCIENCE AND MATHEMATICS. The annual dues for this class shall be two dollars.

Class B shall include all active members, who being members of other scientific societies, do not want the official publication.

The annual dues for this class shall be one dollar.

Resolution adopted.

Voted that we have a permanent committee of three on publication; a Chairman, a Secretary, and one other; that the Chairman and the Secretary of this committee be Associate Editors of SCHOOL SCIENCE AND MATHEMATICS, and the Secretary of this committee be the Chairman of the committee the following year.

II. The following resolution was presented by E. R. Smith of North High School, Syracuse, N. Y.:

Resolved, That the ex-Secretaries and Treasurers of this Association be no longer exempt from the payment of annual dues, and therefore no longer regarded as honorary members.

Resolution adopted.

The following resolutions were presented by J. A. Randall of Pratt Institute, Brooklyn:

III. Resolved, First, That the retiring Vice President appoint a committee of three on syllabus revision for physics, a similar committee on chemistry, one on biology and also one on physical geography.

Second, That the Vice President appoint a committee on improvement in science teaching to formulate and present a statement to the new Commissioner, to each member of the Board of Regents. The statement shall represent the consensus of opinion of the members of the Association as to the best plan of inspection and examination, by which the efficiency of science teaching may be improved and the evolution of methods hastened. The committee shall present syllabi and in other needful ways represent this Association.

The chairman of each committee on syllabus revision shall be a member of the Committee on Improvement of Science Teaching. The Vice President shall appoint one member at large.

Third, That the proposed action of these committees shall be approved by the executive council before they are officially taken.

The above resolutions were unanimously adopted.

IV. Voted that the executive council be empowered and directed to make all needful arrangements for local meetings of members of this Association.

V. Committee on Resolutions offered the following report.

At the close of the 1913 session of the New York State Science Teachers' Association, the committee offers the following for your consideration.

Resolved, First, That we express our indebtedness and gratitude to the chamber of commerce, the board of education, the high school teachers' association, and other local organizations that have contributed to the pleasure of our stay, and the convenience and success of our meeting.

Second, That we are grateful for the most graceful act of the Western Electric Company in granting the use of its rooms for conference purposes.

Third, That we highly appreciate the advantages derived from the exhibits made, and extend our thanks to the authors of such exhibits.

Fourth, That we are mindful of, and express our thanks for the courtesy and coöperation shown by the officers of other educational bodies meeting at this time and place.

Fifth, That our most cordial thanks are due and are hereby tendered to the officers of this Association, and to those who have appeared on the programme, for the sacrifices they have made and the work they have effectually accomplished.

CHAS. NEWELL COBB,
D. A. CADY,
W. M. SMALLWOOD,
Committee.

VI. Committee on Nominations offered the following:

President—Guy A. Bailey, Normal School, Geneseo, N. Y.

Vice President—John A. Randall, Pratt Institute, Brooklyn, N. Y.

Secretary-Treasurer—Ernest F. Conway, Central High School, Syracuse, New York.

Council 1917—Miss Ida L. Revely, Wells College, Aurora, N. Y.; Geo. F. Hargitt, Syracuse University, Syracuse, N. Y.; Bryan O. Burgin, Albany High School, Albany, N. Y.

The Secretary-Treasurer offered the following report:

VII. Receipts:

July 15th, from Ex-Secretary-Treasurer	$ 57.31
December 30th, for Dues	96.00
	$153.31
Expenses	67.54
	$ 85.77

VIII. Expenses:

September 19th.	400 envelopes	$ 1.50
September 19th.	50 envelopes	.60
November 20th.	To Mr. Jenks	20.00
December 11th.	Due Cards	4.00
December 26th.	Badges	12.00
December 30th.	Signs	2.35
December 30th.	Postage to date	6.09
December 30th.	Clerical work	12.00
December 30th.	Programs	9.00
		$ 67.54

MATHEMATICS FOR THE INTRODUCTORY HIGH SCHOOLS.

The following courses are to be offered at the California State University this summer by Miss Thermuthis Brookman:

I. A lecture and recitation course including the contents of arithmetic, geometry and algebra appropriate for the seventh, eighth and ninth grades; the historical setting of each subject and approved methods of presentation. Emphasis will be placed upon the applications of mathematical principles in daily life.

Prerequisite: Plane and solid geometry and algebra.

II. *Arithmetic of Investment and Expenditure.* A teacher's course covering the simple commercial transactions of daily life, including personal, checking and savings accounts, division of income, trading, household expenditures, use of loan associations, investments in real estate, insurance, bonds, etc., apportionment of tax levy.

Experts will address the class on modern aspects of the different transactions. Each student will be expected to prepare a report on one or more topics, presenting them as they might be taught in the intermediate grades, with introductory, drill and review problems for the same.

Prerequisite: One year's experience in teaching mathematics in the seventh, eighth or ninth grades.

HOW TWO PLANTS LIKE THE SUGAR BEET AND NASTURTIUM OF WIDELY SEPARATED FAMILIES CAN BECOME DISEASED BY THE SAME TINY BACTERIUM.

One summer a Department of Agriculture pathologist was walking through a sugar-beet field in Utah and saw a patch of leaves, spotted and blotched with black irregular spots. He had seen many beet fields and was familiar with the common leaf diseases, but these black spots were different from any that he had noticed before. He picked a number of the leaves and sent them to Washington to have one of his laboratory assistants examine them and if possible find the cause of the trouble.

It so happened that about a month before this, a man who was interested in growing nasturtiums in Virginia found many of the leaves of his nasturtium bed affected with watery spots. He watched them and found that after a few days the spots turned yellow and later the tissue fell out. He thought perhaps someone interested in plant pathology would like to examine the leaves and might be able to tell him what the matter was and what to do for his plants. So he sent them to the Bureau of Plant Industry. Another laboratory assistant examined these leaves and found the cells in the diseased places filled with bacteria which were very active. She used the laboratory methods for getting this germ out of the leaves and proved that she had the right one that had caused the trouble.

When the dark-spotted sugar-beet leaves arrived in Washington the laboratory assistant examined the leaves and found numerous bacteria in the diseased spots. She isolated these bacteria from the sugar-beet leaves by the usual method and proved that she had the germ that had caused the disease.

For a long time it was thought that these two diseases were caused by two different organisms, as it was natural to suppose, and the two assistants worked out the life histories of the two germs. Then one day while they were talking about their work they discovered from the many tests they had made that instead of different germs the two were exactly alike. They were surprised at this and made many subsequent tests to

prove that they had made no mistakes: then they produced the nasturtium disease on nasturtium leaves, using the germ they had gotten from the diseased beet leaves, and they produced the beet leaf disease on the sugar-beet leaves, using the germ they had gotten out of the nasturtium leaves. These last tests established their case.

As the appearance of these two diseases was entirely different on the two host plants, it is evident that the whole story about a bacteria disease cannot always be determined from its history on one kind of plant. As a general rule parasites are restricted to a single crop or to closely related crops but in some cases the same little germ may be as destructive, or even more destructive to other plants not at all related to the plant on which the disease was first discovered.

YELLOWSTONE PARK IN 1913.

Almost 2,000 more people visited the Yellowstone Park in 1913 than during the season of 1912, according to the report of the Superintendent, recently made to Secretary Lane. The tourist travel has increased 45 per cent since 1906, and was heavier in 1913 than ever before with the exception of 1909, when the Lewis and Clarke Exposition was held in Portland.

The most important work during the year was that in connection with the improvement of the road system.

"The work on the west entrance road," says the Superintendent, "consisted in the widening of 8 miles of road to 25 feet and graveling of this distance to provide subsurface, and the widening of 9 miles to about 18 feet preparatory to final widening to 25 feet. This gives a partially improved road to the belt line junction 10 miles south of Norris Geyser Basin. Contracts for two bridges on the west road have been let, and bridges will be in place at the beginning of the next tourist season. With a continuance of present appropriation, the entire west entrance road will be widened to 25 feet by the end of the 1914 working season, but the improvement of the road will not be finished until several years later.

"The work on the east entrace road to September 30, 1913, consisted in general widening of the most narrow and dangerous portions to 18 feet, which will be the completed width of the road. Complete or partial widening was done on 20 miles of the 28 miles of this road."

"The winter conditions for wild game were again excellent," says the Superintendent. "With plenty of grass, and the snow remaining soft so they could paw through it to get food, the elk, deer, antelope and mountain sheep wintered well and with but little loss.

"During December, January, February, and March, 538 elk were captured in the park near the northern entrance and shipped for stocking public parks and ranges as follows: Eighty to Kings county, Wash.; 50 to Yakima county, Wash.; 40 to Garfield County, Wash.; 50 to Shasta County, Cal.; 50 to Pennsylvania for Clinton and Clearfield counties; 50 to West Virginia; 80 to Arizona; 25 to Hot Springs, Va.; 3 to City Park, Aberdeen, S. D.; 4 to the City Park at Boston, Mass.; 6 to the City Park at Spokane, Wash. One hundred were captured and shipped under direction of the Department of Agriculture, of which 25 went to Sundance, Wyo.; 25 to Estes Park, Colo.; 25 to Walla Walla, Wash.; and 25 to points in Utah. The cost of capture and loading on board the cars at Gardiner was $5 per head, which was paid by the states and parks receiving the elk. The loss in capturing and up to the time of delivery at their destination was but 22 animals out of 538 shipped."

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

371. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Solve
$$(x^2+y^2)\frac{x}{y}=6,$$
$$(x^2-y^2)\frac{y}{x}=1.$$

(From a recent examination paper.)

Solution by Norman Anning, Chilliwack, B. C., and I. L. Winckler, Cleveland, Ohio.

To solve
$$(x^2+y^2)\frac{x}{y}=6, \tag{1}$$
$$(x^2-y^2)\frac{y}{x}=1. \tag{2}$$

The operations indicated in equation (1) have meaning except when $y=0$. Those in equation (2), except when $x=0$.

These restrictions do not apply to the equations:
$$(x^2+y^2)x = 6y, \tag{3}$$
$$(x^2-y^2)y = x. \tag{4}$$

Hence the latter equations admit one pair of values, namely $x=y=0$ which the former do not.

From (3) and (4) by cross-multiplication,
$$x^2(x^2+y^2) = 6y^2(x^2-y^2),$$
$$x^4-5x^2y^2+6y^4 = 0,$$
$$(x^2-2y^2)(x^2-3y^2) = 0. \tag{5}$$

From (3) and (4) by direct multiplication,
$$(x^4-y^4)xy = 6xy,$$
$$xy(x^4-y^4-6) = 0. \tag{6}$$

Taking (5) with either $x=0$ or $y=0$ leads to the inadmissible solution $x=y=0$.

There remain to be solved the two pairs:
$$x^2 = 2y^2,$$
$$x^4-y^4 = 6,$$
$$4y^4-y^4 = 6,$$
$$y_4 = 2,\ y = \sqrt[4]{2}(l,\ i,\ -l,\ -i).$$
$$x^4 = y^4+6 = 8,\ x = \sqrt[4]{8}(l,\ -i,\ -l,\ i).$$
$$x^2 = 3y^2,$$
$$x^4-y^4 = 6,$$
$$9y^4-y^4 = 6,$$
$$y^4 = \tfrac{3}{4},\ y = \sqrt[4]{3/4}(l,\ i,\ -l,\ -i).$$
$$x^4 = y^4+6 = 27/4,\ x = \sqrt[4]{27/4}(l,\ -i,\ -l,\ i).$$

These show that the given equations have 8 solutions; four real, when x and y have the same sign and four imaginary when the signs are different.

372. *Proposed by I. L. Winckler, Cleveland, Ohio.*

The sides of an inscribed quadrilateral are the roots of a given equation of the fourth degree whose roots are all real and positive. Find the area of the quadrilateral, and the radius of the circumscribed circle in terms of the coefficients of the equation.

Solution by F. Eugene Seymour, Trenton, N. J., and M. G. Schucker, Pittsburg, Pa.

Part One: Suppose ABCD is the quadrilateral and let $AB = a$, $BC = b$, $CD = c$ and $DA = d$. By drawing AC the area of the quadrilateral equals triangle ABC+triangle ADB $= \frac{1}{2}(ab \sin B + cd \sin D) = \frac{1}{2}(ab+cd)\sin B$ since the angles B and D are supplemental.

Now from the triangle ABC : $\overline{AC}^2 = a^2+b^2-2ab \cos B$; and from the triangle ACD : $\overline{AC}^2 = c^2+d^2-2cd \cos D = c^2+d^2+2cd \cos B$. Equating these two values of $\overline{AC}^2$ and solving for cos B

$$\cos B = \frac{a^2+b^2-c^2-d^2}{2(ab+cd)}.\quad \text{Then } \sin^2 B = 1-\frac{(a^2+b^2-c^2-d^2)^2}{4(ab+cd)^2} =$$

$$\frac{[2(ab+cd)+(a^2+b^2-c^2-d^2)][2(ab+cd)-(a^2+b^2-c^2-d^2)]}{4(ab+cd)^2}$$

$$= \frac{(c+b+d-a)\ (a+c+d-b)\ (a+b+d-c)\ (a+b+c-d)}{4(ab+cd)^2}.$$

If now we call $a+b+c+d = 2s$.

Then $\sin^2 B = \dfrac{16(s-a)(s-b)(s-c)(s-d)}{4(ab+cd)^2}$. Substituting this value for sin B in the area of the quadrilateral we have

Area $= \sqrt{[(s-a)(s-b)(s-c)(s-d)]}$.

Suppose now the equation whose roots are a, b, c and d is

$$x^4+px^3+qx^2+rx+t = 0,$$

then the following are true:

$$p = -(a+b+c+d)$$
$$q = +(ab+ac+ad+bc+bd+cd)$$
$$r = -(abc+abd+bcd)$$
$$t = abcd.$$

Using the value of s in terms of p the area of the quadrilateral $=$
$\frac{1}{4}\sqrt{[(p+2a)(p+2b)(p+2c)(p+2d)]} = \frac{1}{4}\sqrt{[p^4+2p^3(a+b+c+d)+}$
$4p^2(ab+ac+ad+bc+bd+cd)+8p(abc+abd+acd+bcd)+16abcd]$.

Therefore the area $= \frac{1}{4}\sqrt{[-p^4+4p^2q-8pr+16t]}$.

Part Two: The radius of the circle circumscribing the quadrilateral will be the radius of the circle about the triangle ABC. By dropping a perpendicular from the center of this circle to AC and drawing the radii to A and C we can easily show that this radius $=$ AC/2 sin B. Now if in part one we substitute the value found for cos B in the expression for $\overline{AC}^2$, we find: $\overline{AC}^2 = c^2+d^2+\dfrac{2cd(a^2+b^2-c^2-d^2)}{2(ab+cd)}$ from which, eventually, $\overline{AC}^2 =$ $\dfrac{(ac+bd)(ad+bc)}{ab+cd}$. Substituting this value of AC and the value for sin B as given in part one in the expression for the radius, we have

$$\text{the radius} = \frac{1}{4}\left[\frac{(ab+cd)(ac+bd)(ad+bc)}{(s-a)(s-b)(s-c)(s-d)}\right]^{\frac{1}{2}};\ \text{that is the}$$

$$\text{radius} = \frac{\frac{1}{4}\sqrt{[(ab+cd)\ (ac+bd)\ (ad+bc)]}}{\frac{1}{4}\sqrt{[-p^4+4p^2q-8pr+16t]}},\ \text{from part one.}$$

By multiplying and regrouping $(ab+cd)\ (ac+bd)\ (ad+bc)$

$$= abcd(a^2+b^2+c^2+d^2)+(a^2c^2d^2+a^2b^2d^2+a^2b^2c^2+b^2c^2d^2)$$
$$= t(p^2-2q)+r^2-2tq = r^2-4tq+tp^2.$$

Therefore the radius $= \dfrac{\sqrt{(r^2-4tq+tp^2)}}{\sqrt{(-p^4+4p^2q-8pr+16t)}}$.

Geometry.

373. *Proposed by Nelson L. Roray, Metuchen, N. J.*

The altitude of a right circular cone is 40 and the radius of its base is 10. A plane perpendicular to an element intersects the midpoint of the altitude. Find volume of frustrum. (From a recent examination paper.)

Solution by Nelson L. Roray, Metuchen, N. J.

Let the altitude of the cone intersect the diameter BC of the base at P, the given plane intersect the element AB at D, AP at E and AC at G; also let F be midpoint of major axis DG of ellipse, FH semi minor axis of ellipse, AF intersect BC at R and the plane of AFH intersect base of cone in RS.

From Pythagoras and similar triangles we have

$$AB = 10\sqrt{17}, \quad AD = \frac{80\sqrt{17}}{17}.$$

Also tan DAE $= \frac{1}{4}$ and $\therefore$ tan DAG $= \frac{8}{15}$. DG $=$ AD tan DAG $=$

$$\frac{128\sqrt{17}}{51}, \text{ and DF} = \frac{64\sqrt{17}}{51}, \ \text{AF} = \tfrac{16}{51}\sqrt{4097}.$$

$$\tan \text{DAF} = \frac{\text{DF}}{\text{DA}} = \tfrac{4}{15}. \quad \therefore \angle\text{EAF} = \tan^{-1}\frac{\frac{4}{15}-\frac{1}{4}}{1+\frac{1}{15}} = \tan^{-1}\tfrac{1}{64}.$$

$$\text{PR} = 40 \tan \text{EAF} = \tfrac{5}{8}. \quad \text{AR} = \tfrac{5}{8}\sqrt{4097}, \ \text{RS} = \tfrac{5}{8}\sqrt{255}.$$

And FH $= \frac{16}{51}\sqrt{255}$ since ΔAFH is similar to ΔARS.

$$\text{Vol. of truncated cone} = \tfrac{4000}{3}\pi - \left[\frac{80\sqrt{17}}{3\,.\,17}\cdot\tfrac{16}{51}\sqrt{255}\cdot\tfrac{64}{51}\sqrt{17}\right]\pi$$
$$= \frac{80\pi}{3}\left[50-\frac{4^5\sqrt{255}}{51^2}\right]$$
$$= 3662.11 \text{ cubic units.}$$

374. *Proposed by Philip Fitch, Denver, Colorado.*

To construct a line which shall be the reciprocal of the sum of the reciprocals of three given lines.

I. *Solution by Proposer.*

On the line AO lay off AC $= l_1$ and AB $= l_2$, where B lies between A and C. On CB as base construct a triangle with CD and BD proportional to l_1 and l_2. Bisect the angle at D and let this bisector meet AO at E. Let AE $=$ R.

$$\frac{\text{CE}}{\text{EB}} = \frac{l_1}{l_2} \text{ or } \frac{l_1-\text{R}}{\text{R}-l_2} = \frac{l_1}{l_2}. \quad \therefore \frac{2}{\text{R}} = \frac{1}{l_1}+\frac{1}{l_2}$$

Divide EA into two equal parts by the point F.

Repeat the process using AF and l_3 and the resulting line will be the one required.

II. *Solution by Norman Anning, Chilliwack, B. C.*

Let OA, OB, OC be the given lines. Draw the circle with O as center and with unit radius. Construct the points A′, B′, C′ inverse to A, B, C with respect to this circle. On any line through O lay off

$$\text{OD}' = \text{OA}'+\text{OB}'+\text{OC}'.$$

Then OD, the inverse of OD′, is the required line.

III. *Solution by F. Eugene Seymour, Trenton, N. J.*

Let a, b, c be the given lines and x the required line. Then it is required to find $x = \dfrac{1}{1/a+1/b+1/c}$, that is $1/x = 1/a+1/b+1/c$. Let $y = 1/a+1/b$, that is $ab = (a+b)y$. Y is then the fourth proportional to $(a+b)$, a and b. We are now required to find $1/x = 1/y+1/c$. As before x will be the fourth proportional to $c+y$, c and y.

375. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

On the side of a ten inch square two inches from a vertex, a ray of light proceeds at an angle of 30° with longer sect of that side, the path being within the square. When, after reflections at sides of square, it has described a path 25 inches in length it strikes an object. Locate this object with reference to the sides of the square.

I. *Solution by T. M. Blakslee, Ames, Iowa, and R. T. McGregor, Coleville, California.*

Let ACBD be the given square and let E—the point 2" from D on DA —be the point from which the ray starts. Call F the point where the ray strikes AB. Since AF is less than AE this point is between A and B. Also $AF = 8/\sqrt{3}$ and $EF = 16/\sqrt{3}$. Call G the point where the ray next strikes BC. In the triangle FBG $FB = 10-8/\sqrt{3}$, $FG = 2(10-8/\sqrt{3})$ and $BG = 10\sqrt{3}-8$. As BG is less than 10 G is between B and C. Call H the point in DC where the ray next strikes DC. In the triangle GHC $GC = 18-10\sqrt{3}$, $HC = 2(3\sqrt{3}-5)$ and $HG = 4(3\sqrt{3}-5)$. Hence H is between D and C. Up to point H the ray has travelled $16/\sqrt{3}+20-16/\sqrt{3}+12\sqrt{3}-20 = 12\sqrt{3}$", which is less than 25". Call K the point where the ray next strikes the side AB; this will be between A and B. Since HK is greater than 10" the object the ray meets is somewhere on the line HK, call the point P and draw PK perpendicular to CB and PL perpendicular to DC. Then $PH = 25-12\sqrt{3}$, $LH = \frac{1}{2}(25-12\sqrt{3})$ and $PL = \frac{1}{2}(25\sqrt{3}-36)$. Hence $PK = 5/2$. The object is therefore located 5/2" from CB and $\frac{1}{2}(25\sqrt{3}-36)$" from DC.

II. *Solution by Norman Anning, Chilliwack, B. C.*

Choose two sides of the square for axes of co-ordinates in such a way that the square lies in the first quadrant. Let 1 inch be unit of length.

A ray, starting from (2, 0) at an angle of 30° with the positive direction of the $x=$axis and of length 25 would, if it were not reflected by the sides of the square, end at $(2+25\sqrt{3}/2, 25/2)$ or (23.65, 12.50). For the reflected ray there is the same amount of travel parallel to the axes but it is back and forward and not straight ahead. Of the 23.65 the first 10 is described positively, the next 10, negatively and the remaining 3.65, positively. Of the 12.50 the first 10 is described in the positive direction of the $y=$ axis and the remaining 2.50, negatively.

Hence the reflected ray ends at the point whose co-ordinates are

$$(3.65,\ 10-2.50) \text{ or } (3.65,\ 7.50).$$

CREDIT FOR SOLUTIONS.

366. Mabel G. Burdick, N. P. Pandya of Baroda, India. (2)

367. N. P. Pandya. (1)

371. Norman Anning, A. E. Babbitt, A. Bagard, Paul Baldwin, T. M. Blakslee, Hugo Brandt, Mabel G. Burdick, Liu Chuen, F. W. Gentlemen, A. M. Harding, John Harrell, C. E. Jenkins, Irvin E. Kline, L. M. List, Clarence McCormick (2 solutions), Richard Morris, Harriet L. Pope, J. L. Riley, Nelson L. Roray, M. G. Schucker, Elmer Schuyler, F. Eugene Seymour, George Y. Sosnow, C. C. Steck, Irene Taake, Edward R. Wicklund, I. L. Winckler, Park E. Wineland. (29)

372. A. H. Harding, Nelson L. Roray, M. G. Schucker (2 solutions), F. Eugene Seymour. (5)

373. Norman Anning, T. M. Blakslee, A. M. Harding, R. T. McGregor, Richard Morris, Nelson L. Roray, M. G. Schucker, I. L. Winckler. (8)

374. Norman Anning (2 solutions), T. M. Blakslee, D. J. da Silva (2 solutions), Philip Fitch, Clarence McCormick, Nelson L. Roray, M. G. Schucker, Elmer Schuyler, F. Eugene Seymour, George Y. Sosnow, I. L. Winckler. (13)

375. Norman Anning, T. M. Blakslee (3 solutions), Mabel G. Burdick, D. J. da Silva, Clarence McCormick, R. T. McGregor, Nelson L. Roray, M. G. Schucker, Elmer Schuyler, F. Eugene Seymour, I. N. Warner, I. L. Winckler. (14)

Total number of solutions, 72.

PROBLEMS FOR SOLUTION.

Algebra.

386. *Proposed by Norman Anning, Chilliwack, B. C.*

The H. M. (harmonic mean) of three quantities is the same as the H. M. of the three H. M.'s found by taking the quantities in pairs.

387. *Proposed by F. Eugene Seymour, Trenton, N. J.*

A man's age in 1887 was equal to the sum of the digits in the year of his birth; how old was he?

Geometry.

388. *Proposed by F. Eugene Seymour, Trenton, N. J.*

If similar triangles be circumscribed about and inscribed in a given triangle, the area of the given triangle is the mean proportional between the areas of the circumscribed and the inscribed triangles.

389. *Proposed by Irvin E. Kline, Atlantic City, N. J.*

Is a right section of an oblique circular cylinder a circle? Prove your answer.

390. *Proposed by R. T. McGregor, Coleville, Calif.*

A cylinder one foot in diameter contains water to a depth of four inches. Find the diameter of a ball which when put into the cylinder will be just covered by the water.

VANADIUM STEEL.

Vanadium steel resists both shock and fatigue far better than ordinary steel. Even small quantities of vanadium impart a remarkable toughness to steel. In the manufacture of steel, the vanadium removes both oxygen and nitrogen. According to Charles H. Richardson's *Economic Geology*, which has just come from the press of the McGraw-Hill Book Co., the reason that the effect of 0.5 or 0.3 per cent of vanadium is so general and intense on steel lies in the extreme avidity vanadium has for oxygen. The presence of minute traces of the metal in a bath of molten steel would lead to an immediate and absolute reduction of every trace of iron oxide. The rupture of the best prepared steel is due to traces of the oxides of iron, even microlites of Fe_2O_3 acting like the stroke of a diamond on the thickest glass. Projectiles upon striking armor plate are raised to a very high temperature, but if made of vanadium steel they retain their sharpness and penetrating power.

MEETING OF DOMESTIC SCIENCE TEACHERS.

Is there a domestic science teacher in your school? If so, will you please

1. Let her see this page.
2. Give us her name and address, so that we may send her further literature.

A meeting of high school domestic science teachers is to be held in Chicago, November 27 and 28, 1914. The Central Association of Science and Mathematics Teachers, a well-known organization of college and high school teachers, has recently established a section for us. Among the subjects upon our program are the following:

Differences between high school and grade work in domestic science as to aim, content, method of presentation.

Correlation of domestic science with other high school science.

Dietetics for high school students.

Household economics in high school. (Family budget, household accounting.)

Housekeeping lessons in high school. (House planning; furnishing and care; bedroom and home nursing work; family meals.)

High school domestic art; what besides garment-making.

Other features of this section meeting will be:

An exhibit of note-books. Will you not plan to bring some of your best note-books from this year's classes?

An exhibit of text-books and other literature, charts, illustrative material. Can you not bring something that has helped you—even if it is only a magazine clipping?

An exhibit of up-to-date household appliances. Please send suggestions. Teachers and commercial firms will contribute.

Saturday afternoon excursions will be organized to visit places of interest, e. g., equipments of Chicago schools, in some of which teaching will be carried on to illustrate points discussed in the program; kitchen departments of down-town hotels or stores; food producers' and purveyors' establishments. Let us know what you want most to see, and we will make an effort to arrange it.

Annual membership in domestic science section without journal or general proceedings $1.50. Please send your suggestions and your money *now;* both will do us more good than if sent later. Address Mr. H. R. Smith, Treasurer, 145 W. Park Ave., Highland Park, Ill.

Would you like to have a journal for high school teachers of domestic science? A monthly journal, in which should appear articles from teachers who have been successful in putting original ideas into practice; from the faculties of university and other training schools; from commercial scientific, social, educational experts; in whose columns you may have discussed your inquiry concerning text-books or equipment, materials or appliances, class room methods or devices, recent scientific research or commercial development in matters which concern your work.

It is such a journal that we plan to issue monthly next year, beginning January 1, 1915. Discussion at Thanksgiving meeting. Come and help us.

MINNA C. DENTON, *Chairman Program Committee,*
Lewis Institute, Chicago.

ARTICLES IN CURRENT PERIODICALS.

American Forestry for February; *Washington, D. C.; $2.00 per year, 20 cents a copy:* "The Panama Canal and the Lumber Trade" (10 illustrations), R. C. Bryant; "The Torrey Pine" (11 illustrations), Eloise Roorbach; "Forestry on the Country Estate" (8 illustrations), Warren H. Miller; "Improvement in Range Conditions" (7 illustrations), A. F. Potter; "Woodlot Forestry" (12 illustrations), R. Rosenbluth; "Initiating a State Forest Policy in Kentucky" (5 illustrations).

American Journal of Botany, Brooklyn Botanic Garden, Brooklyn, N. Y.; $4.00 per year, 50 cents a copy: "The Development of Agaricus arvensis and A. comtulus," Geo. F. Atkinson; "Studies of teratological phenomena in their relation to evolution and the problems of heredity. 1," Orland E. White; "Nuclear behavior in the promycelia of Caeoma nitens Burrill and Puccinia Peckiana Howe," Louis Otto Kunkel; "An axial abscission of Impatiens Sultani as the result of traumatic stimuli," Ross Aiken Gortner and J. Arthur Harris.

American Mathematical Monthly for February; *5548 Kenwood Ave., Chicago, Ill.; $2.00 per year:* "The Algebra of Abu Kamil," L. C. Karpinski; "A Curious Convergent Series," A. J. Kempner; "The Perfect Magic Square for 1914," V. M. Spunar; "Notes on a Memory Device for Hyperbolic Functions," F. S. Elder.

Condor for January-February; *Hollywood, Calif.; $1.50 per year, 30 cents a copy:* "Frontispiece: Inattentive—White-faced Glossy Ibises at Laguna Blanca," W. Leon Dawson; "Direct Approach as a Method in Bird Photography (with eight photos)," W. Leon Dawson; "Notes on the Derby Flycatcher," Adrian van Rossem; "Some Notes on the Nesting of the Sharp-shinned Hawk (with eight photos)," Henry J. Rust; "The People's Bread—A Critique of 'Western Bird Guide,'" W. Leon Dawson; "A Second List of the Birds of the Berkeley Campus," Joseph Grinnell.

Journal of Geography for March; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Historic Mountain-passes of the World," Minnie J. Langwill; "Remarks on Geography in America," Albert Perry Brigham; "The Japan Current and the Climate of California," William G. Reed; "Notes on Wall Maps," Robert M. Brown; "Current Information about Mexico"; "Geographical Notes: Cacti as Emergency Forage, Progress of Porto Rico in 1913, Commercial Cuba, The Commerce of Chili, Panama and the Canal, The Outlook for Meat Production, The British Channel Tunnel, Sugar in Argentina, Marketing Farm Products, West Virginia Coal"; "The Yogo Sapphire Mines, Montana," O. W. Freeman; "Geography in the University of South Africa"; "The Great Lakes in a Cold Wave," Mark Jefferson.

L'Enseignement Mathématique for January; *Stechert & Co., West 25th Street, New York; 15 francs per year, 2 francs per copy:* "L'utilisation de la géométrie non-euclidienne dans la physique de la relativité," L. Rougier; "Egalités multiples de G. Tarry," A. Aubry; "Sur l'intégration des équations du mouvement d'une planète autour du soleil," W. Ermakoff; "Sur quelques points de la théorie des ensembles," D. Mirimanoff; "Sur la construction des courbes transcendentes planes dont les équations sont à coordonnées séparées," É. Turrière; "Sur un double système de lignes d'une surface," R. Occhipinti; "Une application de la méthode de fausse position," L. Ballif; "Sur les triangles heroniens. Nouvelles formules," N. Gennimatas.

Mathematical Gazette for January; *G. Bell & Sons, Portugal St., Kingsway, London; six no., 9s. per year, 1s. 6d. per copy:* "The Constitution of the Teaching Committees of the Association"; "Report of the General Teaching Committee, 1912-1913"; "The Summer Meeting of the London Branch—Flatland"; "Mathematics in Secondary Schools"; Questionnaire on the Teaching of the Calculus in England, and Report," C. Godfrey; "The Teaching of Numerical Trigonometry *(Concluded)*," J. W. Mercer; "The Calculus as an Item in School Mathematics,' C. S. Jackson.

Nature-Study Review for February; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "The Beginning of Star Study," Mrs. A. B. Comstock; "Use of Material by Young Nature Students," R. W. Shufeldt; "The School

Gardens of Saginaw, Kate M. Passolt; "A Day's Hygienic Living," C. A. Stebbins; "The Woodlawn School Garden," Alice V. Joyce; "Supervising a Community Garden," Elizabeth M. Waters.

Photo-Era for February; *383 Boyston Street, Boston; $1.50 per year, 15 cents a copy:* "Winter-Sports Photography," Will Cadby; "Making Lantern-Slides at Home," Allen E. Churchill; "Copying Up to Date," E. J. Wall; "The Amateur and the Photo-Supply Salesman," A. H. Beardsley.

Physical Review for February; *Ithaca, N. Y.; $6.00 per year, 50 cents a copy:* "The Electrical Discharge from Liquid Points, and a Hydrostatic Method of Measuring the Electric Intensity at their Surfaces," John Zeleny; "Notes on Quantum Theory. A Theory of Ultimate Rational Units; Numerical Relations between Elementary Charge, Wirkungsquantum, Constant of Stefan's Law," Gilbert N. Lewis and Elliot Q. Adams; "Discharge in a Magnetic Field," Robert F. Earhart; "Anomalous Temperature Effects upon Magnetized Steel," N. H. Williams; "Calculation of a Damping Rectangle to Produce Critical Damping in a Moving Coil Galvanometer," Paul E. Klopsteg; "Change of Phase Under Pressure. 1. The Phase Diagram of Eleven Substances with Especial Reference to the Melting Curve," P. W. Bridgman.

Popular Astronomy for March; *Northfield, Minn.; $3.00 per year, 15 cents a copy:* "Astronomical and Astrophysical Society of America, Report of the Sixteenth Meeting"; "Review of Sunspot Observations made at Alta, Iowa, during the Past Seven Years 1907 to 1913," David E. Hadden; "Drawings of Mars 1914, with Plate VII," Latimer J. Wilson; "The Martian Markings, with Plates VIII-XI," E. C. Slipher; "Monthly Report on Mars,—No. 3," William H. Pickering.

Popular Science Monthly for February; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "The Physical Laboratory and Its Contributions to Civilization," Arthur G. Webster; "The Origin and Evolution of the Nervous System," G. H. Parker; "Current Progress in the Study of Natural Selection," Dr. J. Arthur Harris; "The Hibernation of Certain Animals," the Late Walter L. Hahn; "Some Abnormalities in Apple Variation," W. J. Young; "Science and Poetry," Dr. Charles W. Super; "The Rural Opportunity and the Country School," Joseph W. Strout; "Early Geological Work of Thomas Nuttall," Dr. Charles Keyes; "The Struggle for Equality in the United States," Charles F. Emerick.

School Review for March; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Reorganization of Secondary Education in New Hampshire. 1," H. A. Brown; "Physical Training with Special Corrective Work and Hygiene (Including Sex Hygiene) in Girls' High Schools," Florence H. Richards, M. D.; "The Vocational Interests, Study Habits, and Amusements of the Pupils in Certain High Schools in Iowa," Irving King.

School World for February; *Macmillan and Company, London, Eng.; 7s. 6d. per year, 6 pence a copy:* "The Influence of the Older Universities on the Curricula of Secondary School," A. C. Benson; "The Teaching of History," Rev. Canon J. Howard B. Masterman; "Educational Problems Yet to be Solved," Lord Bryce; "Thirty Years' Progress in Geographical Education," J. Scott Keltie; "Conditions and Results of Science Teaching," H. B. Baker; "Relations among the Staff in Secondary Schools,' Frances E. Tooke.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 1; *Otto Salle, Berlin, W. 57, Germany; M. 4.— per year, 60 Pf. per copy:* 'Unsere gegenwärtigen Anschauungen über Röntgenstrahlung," Prof. Dr. A. Sommerfeld; "Der Strahlengang im Fernrohr," Prof. Dr. W. B. Hoffmann; "Was versteht man unter 'Angewandter Mathematik'" Prof. Dr. A. Thaer; "Gemeinsame Tangenten zweier Kreise," Oberlehrer R. Winderlich; "Einige diophantische Gleichungen höheren Grades," Oberlehrer Prof. Hesse; "Zum c. a. der sphärischen Trigonometrie," Dr. Fritz Thaer; "Kinetischer Beweis des Aussenwinkelsatzes," Oberlehrer Gustav Grimm; "Zur stetigen Teilung am gleichschenkligen Dreieck," Oberlehrer Dr. R. v. Förster.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for February; *B. G. Teubner, Leipzig, Germany; 12 numbers, M. 12. per*

year: "Der Satz des Ptolemäus," Milan Zdelar; "Der Pythagoreische Lehrsatz," Milan Zdelar; "Wie bestimmt man in der Schule die Neigung und die Knoten der Mondbahn?" P. Kiesling; "Der Schwerpunkt im Dreieck," Dr. Karl Krüse; "Ueber die graphische Behandlung von Zinseszins—und Rentenaufgaben," B. Reismann; "Ueber die reziproken Gleichungen," Prof. Leman; "Geometrische Darstellung einer besonderen Art unendlicher Reihen," Dr. Otto Förster; "Der Lehmus-Steinersche Satz," W. W.; "Die konische Loxodrome," H. Pfaff; "On the sum of a family of series," I. J. Schwatt; "Zur Geometrographie," Edited by K. Hagge.

LUMBERING GREATEST MANUFACTURING INDUSTRY.

According to E. T. Allen of Portland, Oregon, lumbering is the greatest American manufacturing industry and is exceeded only by agriculture in supplying the essentials of life. In a recent address before the conservation congress he called attention to the comparative lack of the public's knowledge of the economics of subjects which touch each individual so closely as forestry and lumbering.

Mr. Allen is forester of the western forestry and conservation association, an organization of lumbermen whose principal activity is the protection of their holdings from fire. A large part of the association's efforts are directed to making the public realize the loss which each individual suffers, directly and indirectly, from forest destruction. In this connection he pointed out that forest preservation can not be conducted wholly by business managers or boards of directors. "It is a mutual co-operative enterprise," he said, "requiring daily participation by all concerned. The American forest policy must exist not because a few say it should, but because a majority of citizens understand what is needed and why it is needed and put the policy into effect."

"The only reason the average citizen does not realize the importance of forestry and does not give it the same active and intelligent interest that he gives his home town problems is that he can not see it so clearly. The very immensity and importance of the lumber industry causes its several processes of growing, manufacturing, and distributing to be conducted separately, and this confuses the public mind. Different communities see different parts of the whole process, but get no thorough grasp of forest economics.

"In many a little German village the whole community sees the forest grown, cut, manufactured, and used. Those who do not actually participate serve or supply those who do. Their forestry needs no propaganda. The people could not understand the need for it any more than of propaganda for raising wheat and making bread.

"We talk too much about forests as though they were an end in themselves. We might just as well talk only of land when trying to improve agricultural conditions, or of water when urging the protection and propagation of food fishes. The average citizen must be brought to consider all forest production and all forest use as little or no different from the production and use of any necessary crop, obviously to be encouraged and stabilized on a permanent basis profitable to all concerned. Whether he is a private citizen or a law maker serving private citizens, he must be familiar with all the factors. As long as he thinks an uncut forest is forestry, and that such forestry is good and all lumbering bad, there will be no real progress.

"There is little trouble in passing laws for the protection and advance of agriculture, horticulture, and dairying, because people understand the governing conditions of these industries and see the point of such laws readily.

"To succeed in the United States forestry must be so closely allied with lumbering that neither forester, lumberman, nor public makes any distinction. This being true, the need is to teach the principles of the business from start to finish. Every process, its cost, and its relation to other processes and to the final price of the product should be common knowledge. The education of the public along these lines is the greatest need in forestry today."

MEETING OF OHIO TEACHERS OF SCIENCE AND MATHEMATICS.

The tenth annual meeting of the Association of Ohio Teachers of Mathematics and Science will be held at the Ohio State University, Columbus, Ohio, on Friday evening, April 3rd and Saturday, April 4th.

The Friday evening session will consist of an address by Jas. F. Barker, Principal of East Technical High School, Cleveland, Ohio, on Technical and Manual Training High Schools, Vocational and Continuation Schools, and Grade and Industrial Schools. At the session on Saturday morning Professor H. E. Slaught of the University of Chicago, Chairman of the National Committee of Fifteen on a Geometry Syllabus, will address the Association on the final report of that committee. At the afternoon session, Professor A. E. Young of Miami University and Professor G. N. Armstrong of Ohio Wesleyan University will speak. There will also be papers by teachers prominent in secondary school work.

BOOKS RECEIVED.

Bills, School and Mine, by W. S. Franklin, Lehigh University. Pages vii+98. 12.5x18 cm. Cloth, 1913. 50 cents. Franklin, MacNutt and Charles, So. Bethlehem, Pa.

The Bird Notebook, by Anna Botsford Comstock, Ithaca, N. Y. 26 plates. 12.5x19 cm. 30 cents. Comstock Publishing Company, Ithaca, N. Y.

Das Meer, seine Esforschung und sein Leben, von Prof. Dr. Otto Janson, dritte Auflage mit 40 Abbildungen. 113 pages. 12.5x18 cm. Ladenpien geb. M. 1.25.

Das Mitrostop, von Prof. Dr. W. Scheffer, Berlin, zweite Auflage mit 99 Abbildungen. 100 pages. 12.5x18 cm. In Leinwand geb. M. 1.25. B. G. Leubner, Leipzig.

Elementary Chemistry, by Alexander Smith, Columbia University. Pages viii+439. 13x19 cm. Cloth, 1914. $1.25. The Century Company, New York City.

Elements of Electricity for Technical Students, by W. H. Timbie. Pages xiii+554. 14x20 cm. Cloth, 1914. John Wiley & Sons, New York City.

A History of Japanese Mathematics by David E. Smith and Yoshio Mikami. Pages vii+288. 15.5x23.5 cm. Cloth, 1914. $3.00 net. Open Court Publishing Company, Chicago.

A Study of Education in Vermont, by the Carnegie Foundation. Bulletin number seven. 214 pages. 19x25.5 cm. Paper.

Transactions of the Illinois Academy of Science. Vol. VI. 138 pages. 15x23 cm. Paper. Published by the Academy, Springfield.

High School Physics, by John O. Reed and William D. Henderson, University of Michigan. Pages vii+410. 13.5x19 cm. Cloth, 1913. Lyons and Carnahan, 623 S. Wabash Ave., Chicago.

BOOK REVIEWS.

The Chemistry of Plant and Animal Life, by Harry Snyder. Third revised edition. Pages 388+xxii. 14x19x3 cm. Cloth. 1913. $1.50. The Macmillan Company, New York.

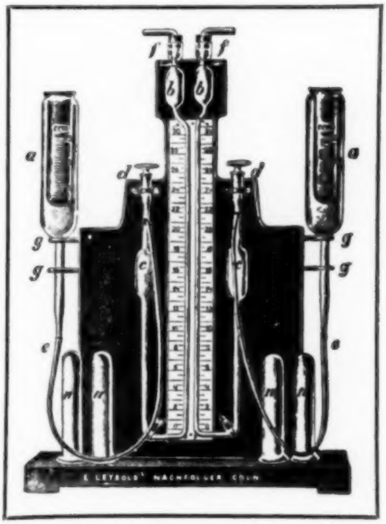
A large number of facts is presented in Part II of this book. These facts are of a sort which would concern students of agriculture, chiefly. Part II occupies about two-thirds of the volume. In Part I an attempt is made to furnish something of a basis for Part II. The principles of general inorganic chemistry are briefly set forth in this part. No adequate foundation of organic chemistry is provided although much of the material of Part II requires a good preparation in organic chemistry if the facts are to be comprehended in their relations to each other. The book has a decidedly utilitarian trend and will serve students who expect to engage in agriculture and who have not the time to take a thorough course of preparation in the underlying sciences. F. B. W.

Practical Mathematics, by Norman M'Lachlan, Superintendent of Walton and Kirkdale Technical Institute and Special Supervisor of Engineering in the Technical Institute, Liverpool, England. Pages vi+184. 13x19 cm. 1913. 80 cents. Longmans, Green & Co., New York.

While this book is designed for day and evening classes in technical schools, it can be used to great advantage as a supplementary text-book in plane and solid geometry in high schools. It is a real application of the principles of geometry to the problems of the shop and to the simpler engineering problems with which the high-school pupil comes in contact directly or indirectly in his daily life. No great technical knowledge is required in the use of this book since explanations of technical terms are given whenever they are necessary. The chapters cover the following topics in order: Plane rectilinear figures, the right triangle (including angle functions), the circle, the ellipse, the cube, the prism, the cylinder, the cone, the sphere, and transformation of formulas. There are 119 problems worked out and 451 for solution. Teachers of geometry who are looking for applications of geometry will find this book of great service. H. E. C.

Models to Illustrate the Foundations of Mathematics, by C. Elliott. Pages viii+116. 14x22 cm. Paper. 1914. Price 2s. 6d. Lindsay & Co., Edinburgh.

It is the purpose of the author to bring some of the modern views on the foundations of mathematics within the grasp of beginners. By giving less emphasis to abstract reasoning and more to observation and description he hopes to introduce the elements of modern pure mathematics in an earlier stage of mathematics teaching. Mathematics is regarded as the science of classification, and two fundamental ideas of elementary mathematics, that of a correspondence or function and that of a multiplex, are readily illustrated by so-called classificatory models, that is, model or artificial classifications showing the features under discussion. The contents are as follows: Chapter I. The Meaning of Correspondence. A correspondence is regarded as a classification and cross-classification of the things which correspond. Chapter II. Multiplexes. For example, duplexes, triplexes, quadruplexes. Chapter III. Spaces. By these are meant ordered multiplexes; for example, if both sets of classes in a duplex have definite orders, the duplex is regarded as a "space" of two dimensions. Chapter IV. Correspondence of Operands to Functions, including the elementary idea of one-to-one correspondence, and of a group. Chapter V. Multiple Correspondence, that is, the correspondence to each other of the members of multiplexes. H. E. C.



Theory of the Irreducible Cases of Equations, Part II, by Charles E. White, Professor of Mathematics in West Virginia Wesleyan College, Buckhannon, W. Va. Pages v+90. 16x23 cm. 1913. Price 75 cents. Published by the author from whom copies may be ordered.

College students and high-school teachers interested in general methods of solving equations of the third and higher degrees will be interested in this volume since it contains much material of real value not found elsewhere. The author believes that the following solutions, methods, and constructions given in this book are new: The methods of deriving trigonometric formulas for the solution of cubics and the solutions by algebraic formulas; the solutions of the irreducible cases of equations of the third, fourth, fifth, sixth, seventh, and higher degrees; the methods of computing trigonometric functions and their logarithms; a method of computing logarithms; the methods of computing the length of chords, subchords, and middle ordinates; a method of finding the length of arc; the practical trisection of an angle and the trisection by integraph, ruler and compasses; the method of deriving the equations upon which the inscription of polygons depends; and the practical construction with ruler and compasses of regular polygons of seven, nine, thirteen, and seventeen sides.

The various methods and constructions are presented with clearness, and illustrated with worked-out problems and exercises. There are more than one hundred exercises and problems for solution. H. E. C.

Second Course in Algebra, by Webster Wells, and Walter W. Hart, University of Wisconsin. Pages v+285. 13x18 cm. 1913. D. C. Heath & Co., Boston.

The first nine chapters give a review of the work of the first year, and with the remaining chapters cover the usual college entrance requirements. The exercises and problems are for the most part new and include many practical applications, and some graphical work. Throughout the book simple exercises are selected for the text, while more difficult ones are given in supplementary lists at the close of chapters. H. E. C.

Molécules Atomes et Notations Chimiques, fourth volume of a series, "Les Classiques de la Science." The present volume contains original papers *by Gay-Lussac, Avogadro, Ampère, Dumas, Gaudin and Gerhardt.* In French. Pages 116+xii. 13x19.5x1 cm. 1913. One franc 20 centimes. Librairie Armand, Colin, Paris.

This little volume is one of a series of French reprints of science classics resembling in character the well known Alembic Club reprints in English. The committee of publication consists of M. H. Abraham, H. Gautier, H. le Chatelier and J. Lemoine. They announce in a preliminary note that it is their intention "to present successively to the scientific public fundamental memories of French and foreign savants, which have opened the great chapters of science."

The committee also calls attention in this notice to the value of reading original papers "as the best means of developing in students the scientific spirit, while contributing also to their literary culture." They quote an article by Lucien Poincare in which he says in answering the objection that original papers are too profound for elementary pupils, that "you will agree that this or that page written by a Pascal, an Arago or a Berthelot has in its profoundness more of luminous clearness and more of real simplicity than the corresponding chapters of many treatises, called elementary, where the authors, who seldom reach original sources and who copy often one from another, have reproduced with deformities more and more vexatious the first thought of the originators."

This little book will be found of value to all secondary teachers who read the French language and the translation of passagess from it when

the several subjects come up in the chemistry course will help to give a clear understanding of the problems in hand and at the same time serve to stimulate interest in the work. Pupils who read French will be found to be more than anxious to read these original papers themselves if led to make the attempt and in most cases where some previous knowledge of the subject matter has been gained they will find the reading comparatively easy. F. B. W.

Experiments for Students in General Chemistry, shorter course, by Edgar F. Smith, Blanchard, Professor of Chemistry, University of Pennsylvania, and Harry F. Keller, Professor of Chemistry, Central High School of Philadelphia. Pages 56. 19x12x.8 cm. 1913. Price, 60¢ net. P. Blakiston's Son & Co., Philadelphia.

A laboratory manual. The order is a systematic one rather than a natural one. Directions are perhaps too brief and compact for younger pupils. More drawings would be helpful. The second part deals with the reactions of the metals and the treatment is evidently designed to lead up to systematic qualitative analysis. This method of gradual approach to regular qualitative work is to be commended. There are numerous good leading questions and many suggestions that reference work be done.
F. B. W.

Industrial Chemistry for Engineering Students, by Henry K. Benson, Ph. D., Professor of Industrial Chemistry in the University of Washington. Pages xiv+431. 14x19x3.5 cm. 1913. $1.90. The Macmillan Company, N. Y.

The book, as its title indicates, is essentially a condensed text-book of industrial chemistry. The more essential topics such as fuels and combustion, are given fuller treatment than other less fundamental topics. The discussions of the underlying principles which precede the discussions of the practice, under each topic, are to be especially commended. The very full bibliographies at the close of each chapter afford opportunity for more complete study to those whose ambition leads them to desire fuller information in regard to any topic. In addition to its use as a text for engineering students, the book might well find a place in the library of every secondary school teaching chemistry, for use as a reference work. Among the practical applications of chemistry which could well be referred to by high school pupils were noted—fuels and combustion, including a discussion of smoke prevention—water softening—the metallurgy of iron and steel—industrial alloys—the manufacture of lime and cement and of explosives. F. B. W.

Plane and Solid Geometry, by Walter B. Ford, Junior Professor of Mathematics, The University of Michigan, and Charles Ammerman, The William McKinley High School, St. Louis, Mo. Edited by Earle R. Hedrick. Pages ix+321+xxxiii. 13x19 cm. Price, $1.25. 1913. The Macmillan Company, New York.

The *Plane Geometry* was reviewed in the December, 1913, number of this Journal. The *Solid Geometry* seems to have been planned and written with the same care and attention to details which characterizes the *Plane Geometry*. For the most part each theorem is followed by several exercises, and there are a number of pages of excellent numerical problems and applications. Cavalieri's theorem and the prismoid formula are included in this book, as they should be. Many "phantom" halftone engravings give the pupils a picture of the solids which makes the theorem and the proof seem real. This *Plane and Solid Geometry* is one of the best geometry texts that have appeared in recent years and ought to be used in many high schools. H. E. C.

Spherical Trigonometry, by Robert E. Moritz, Professor of Mathematics, The University of Washington. Pages vi+67. 15x23 cm. Price, $1.00. 1913. John Wiley & Sons, Inc., New York.

In the production of this book the author has followed in general the plan adopted in his plane trigonometry. This insures clear and adequate statement of principles, good methods of presentation of topics, and good lists of applied problems. A proof of Napier's Rules of Circular Parts is given probably for the first time in an elementary text-book. H. E. C.

Technical Algebra, Part I, by Horace W. Marsh, Head of the Department of Mathematics, School of Science and Technology, Pratt Institute. Pages xvii+428. 14x21 cm. Price, $2.00. 1913. John Wiley & Sons, Inc., New York.

It is evident that the author depends largely on his *mathematics work-book* to interest his pupils in algebra. The pupil puts all his work in this loose-leaf notebook, doing most of the work in the class-room. It would seem that this text-book requires some such device for it is largely composed of long lists of abstract forms and equations for manipulation, and long lists of formulas from physics and engineering for transformation and evaluation.

The introductory chapter is a type of all the work. There is in it a list of 105 formulas which are to be solved for one or more of the letters involved, or are to be evaluated for given values of the letters; it also contains the statements of 140 laws which the pupils are to formulate. The author states that one means of concentration is to use laws regarding things of which the pupil has little or no knowledge but with which he will become familiar in later industrial studies. The laws are stated clearly and with the necessary drawings and diagrams, and under the guidance of a well-informed and enthusiastic teacher the pupils no doubt would learn more than the mere manipulation of forms.

The gathering together of the several hundred formulas in this book makes it at least a convenient reference book, insofar as the letters entering into the laws are defined. The chapters on logarithms and the slide-rule are said by the author to be the most complete yet written on these subjects. All the usual topics of high school algebra are included. The book is well arranged and well printed. Indeed, it is a pleasure to look through this volume. H. E. C.